Journal of Agricultural Sciences (Belgrade) https://doi.org/10.2298/JAS2004321N
Vol. 65, No. 4, 2020 UDC: 635.112:631.86(548.7)
Pages 321-335 Original scientific paper

THE EFFECTS OF GOAT MANURE AND SUGARCANE MOLASSES ON THE GROWTH AND YIELD OF BEETROOT (*BETA VULGARIS* L)

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Abstract: A pot experiment was conducted to study the effect of goat manure and sugarcane molasses on the growth and yield of beetroot (*Beta vulgaris L.*) in sandy regosol. The experiment was laid out in a completely randomized design (CRD) with six treatments. The treatments included inorganic fertilizer (T1), 10 t/ha of goat manure alone (T2) and also 10 t/ha of goat manure and 50% triple superphosphate (TSP) with 1–4 t/ha of sugarcane molasses (T3-T6). The results showed that plant growth parameters (leaf length, leaf petiole length, leaf width, leaf number, fresh weight and dry weight of leaves) were significantly varied among the treatments. There was a significant difference in the diameter of beetroot among the treatments. Significant differences ($P<0.05$) were observed in fresh weight of beetroot and total plant among the treatments. Fresh weight of root yield and total yield of beetroot per plant were increased in 10 t/ha goat manure, 2 t/ha sugarcane molasses and 50% TSP (T4) and 10 t/ha goat manure, 3 t/ha sugarcane molasses and 50% TSP (T5) when compared to the control treatment (T1). The total yield of beetroot per m^2 was 1,792.62 g in T4 and 1,402.68 g in T1. The root yield of beetroot was increased in T4 in comparison to T5. It can be concluded that 10 t/ha of goat manure with 2 t/ha of sugarcane molasses and 50% TSP could be applied for obtaining a high yield of beetroot in sandy regosol.

Key words: beetroot, goat manure, molasses, yield.

Introduction

Beetroot (*Beta vulgaris* .L) belongs to Chenopodiaceae family. It is grown widely in Sri Lanka. Beetroot is good for health as it contains minerals, vitamins, fiber and medicinal properties. This crop is one of the most noteworthy vegetables with regard to antioxidant properties, primarily owing to the presence of betatains (Ullah and Khan, 2008; Nahla et al., 2018). In some countries, beetroot pigment is commercially used as red food dye in diverse products. *Beta vulgaris* var. rubra has considerable anticancer properties (Kapadia et al., 1996). Beetroot is an annual vegetable crop grown for its root, and commonly grown beet varieties are detroit

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dark red and crimson globe. In Sri Lanka, it is grown in all agroecological regions but effectively cultivated in Nuwara Eliya, Badulla, Kandy and Matale districts. Beets prefer well-drained fertile sandy loams to silt loams with high organic matter for better root development.

Inorganic fertilizers release nutrients quickly, therefore, farmers widely use it to supply nutrients for vegetable crops to obtain a high yield, but excessive use of these fertilizers is toxic to human health and causes nutrient loss, groundwater contamination and a decrease in effective microbial communities (Chen, 2006). On the other hand, the use of organic manure improves soil physical and chemical properties and provides favorable conditions for crop growth with less environmental impact (Suthamathy and Seran, 2009). The application of organic manures can increase crop yield and soil fertility more than chemical fertilizer (Murmu et al. 2013). Hence, the residual effects of organic manure or compost application increased crop production for at least one growing season (Eghball et al., 2004; Imthiyas and Seran, 2017).

The use of locally available organic manures with a reduced level of inorganic fertilizers could give a greater seed yield than inorganic fertilizers alone (Seran, 2016; Raveenthira and Seran, 2020). Ojeniyi and Adegboyega (2003) reported that the application of goat manure remarkably increases nitrogen (N), phosphorous (P), potassium (K), calcium (Ca) and magnesium (Mg) in the leaf of celosia plant. Sugarcane molasses are ones of the economically important agricultural crops grown in tropical regions, and they are produced annually in large amounts (De la Rosaa et al., 2019). They are a byproduct of sugar industries which have been used in agriculture as an organic source of fertilizer. It contains sugar, minerals, vitamins, ash and polyphenols (Takara et al., 2007; Jain and Venkatasubramanian, 2017; De la Rosaa et al., 2019). The use of sugarbeet molasses in crop cultivation accelerates nutrient uptake efficiency and soil biological activity (Samavat and Samavat, 2014). The application of organic manures improves the water holding capacity of soil and supplies both macro and micro plant nutrients for achieving better crop yield. Therefore, this experiment was aimed to determine the effect of the combined application of goat manure and sugarcane molasses with a reduced level of phosphorus (P) inorganic fertilizer on the growth and yield of beetroot and also to find out the optimum rate of molasses with 10 t/ha of goat manure as a basal application for a high yield of beetroot in sandy regosol. The finding is useful to beetroot growers for obtaining high yield with less use of inorganic fertilizer.

Materials and Methods

A pot experiment was carried out in the Crop Farm of Eastern University, Sri Lanka in 2018–2019. This area comes under the agroecological zone of the low country dry zone. The annual rainfall ranges from 1800 to 2100 mm. The annual mean temperature is 32±3˚C and the humidity level nearly 60%–80%. The type of soil is sandy regosol. A pot experiment was laid out in a completely randomized design (CRD) with six treatments and ten replications. Treatments included in this experiment are as follows.

T1: Recommended NPK inorganic fertilizers;
T2: 10 t/ha GM + 0 t/ha SM + 50% TSP;
T3: 10 t/ha GM + 1 t/ha SM + 50% TSP;
T4: 10 t/ha GM + 2 t/ha SM + 50% TSP;
T5: 10 t/ha GM + 3 t/ha SM + 50% TSP;
T6: 10 t/ha GM + 4 t/ha SM + 50% TSP;
GM: Goat manure;
SM: Sugarcane molasses;
50% TSP: Half dosage of recommended tripe super phosphate.

Sugarcane molasses were collected from the Galoya Plantation (Pvt) Ltd, Hingurana, Ampara, Sri Lanka and goat manure was obtained from Animal farm, Eastern University, Sri Lanka. According to the treatments, goat manure (1.73% N, 0.47 P_2O_5, 1.67% K_2O) and sugarcane molasses (0.53% N, 0.043 P_2O_5, 1.48% K_2O) were taken and mixed with soil to prepare the soil mixture. The polybags (30 cm height and 30 cm diameter) were filled with soil mixture, and holes were made at the side and base of each polybag to facilitate the drainage of water.

Seeds of beetroot cv. crimson globe were collected from the Department of Agriculture, Nuwaraeliya, Sri Lanka. Two seeds were placed in each polybag, but only one healthy seedling was maintained in each polybag one week after seedling emergence. Inorganic fertilizers as basal (165 kg/ha urea, 270 kg/ha tripe superphosphate, 125 kg/ha muriate of potash) and top dressing (165 kg/ha urea, 125 kg/ha muriate of potash) were applied to control treatment (T1) as recommended by the Department of Agriculture, Sri Lanka. Other treatments, that is, T2-T6, 10 t/ha goat manure and 0–4 t/ha sugarcane molasses with half dosage of recommended tripe superphosphate (TSP) were applied as described above. Irrigation was done twice a day in the morning and evening by using a watering can. Weeding was done manually.

In this experiment, leaf, root and yield parameters in all treatments were collected at harvesting time. Plant height was measured using a meter scale in each plant. The number of leaves per plant was counted. Length and width of leaf, petiole length and edible root length (cm) were measured with the aid of a ruler while the diameter of the edible root was measured with the aid of a vernier calliper. The chlorophyll content of leaves was measured using a chlorophyll meter (SPAD 502 plus). The shoot (above-ground level plant part) and edible root portion of each plant in all treatments were separated and their fresh weights (g) were measured. These materials were cut into small pieces, separately dried at 105^0C for 1 hour in an oven, and their dry weight (g) was recorded using an electronic balance. Harvesting was done at 75 days after planting. Total crop yield (g/m^2) and marketable root yield (g/m^2) were calculated. All the collected data for each parameter were analyzed by analysis of variance using the SAS 9.1 statistical software package. The treatment mean was compared by the Tukey's test at the 5% significance level.

Results and Discussion

Plant height

Figure 1 shows the average plant height of the beetroot crop in each treatment. There was a significant variation ($P<0.01$) in plant height among the treatments. Plants treated with T5 (10 t/ha of goat manure, 3 t/ha of sugarcane molasses and 50% of TSP) exhibited maximum plant height (27.4 cm), whereas T1 (inorganic fertilizers as control) had a minimum value of 19.36 cm among the treatments. A significant variation in plant height was observed between T1 and T5, but the difference between T2 (10 t/ha of goat manure alone) and T5 was not significant. Among the treatments, the shortest plant was observed in the control (T1) treatment where NPK inorganic fertilizers were applied at the recommended rate. In addition to primary nutrients, sufficient amounts of secondary macronutrients such as calcium, magnesium and sulfur are important for plant growth. Ojeniyi and Adegboyega (2003) have stated that goat manure also releases essential micronutrients to the soil, and it was found to significantly increase the leaf growth of celosia.

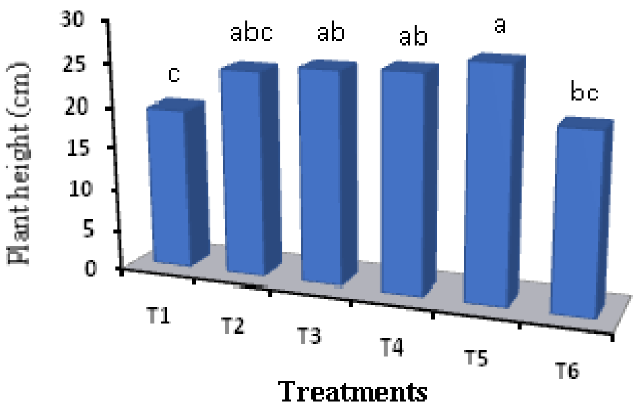

Figure 1. The effect of goat manure, molasses and 50% TSP application on the average plant height of beetroot.

The maximum plant height recorded in T5 may be probably due to favorable application of goat manure and molasses which contain potassium and other nutrients. Nitrogen (N), phosphorus (P) and potassium (K) are the major nutrients essential for plant growth and yield. The high concentration of these primary nutrients is necessary for plants as any deficiency of the essential nutrients will preclude healthier plant growth (Gholizadeh et al., 2009). T6 treatment (10 t/ha of goat manure, 4 t/ha of sugar masses and 50% TSP) produced significantly shorter plants as compared to T5. This may be due to excess potassium ion availability from the high concentration of K fertilizer applied. This result is supported by the findings of Taiz and Zeiger (2006), who suggested that excess ions in nutrient solutions decreased plant growth. Shaibur et al. (2008) reported that potassium ions reduced calcium and magnesium concentrations in rice seedlings.

Number of leaves

There was no considerable difference (P>0.05) in an average number of leaves produced per plant. The minimum value of 6.4 was obtained in T2, while the maximum number of leaves (9.2) was recorded in T5 (Figure 2). This may be due to the high nutrient supply, particularly nitrogen and potassium in the combined application of goat manure and molasses. In this study, the number of leaves per plant was increased by increasing potassium supply to a certain limit then declined as observed in the lower number of leaves in T6 compared to T5. Molasses supply the ion at a higher rate. Serio et al. (2001) mentioned the lower rate of lettuce leaf production under the higher electrical conductivity value in soilless conditions. The leaf surface area is important for the physiological activity of the plant.

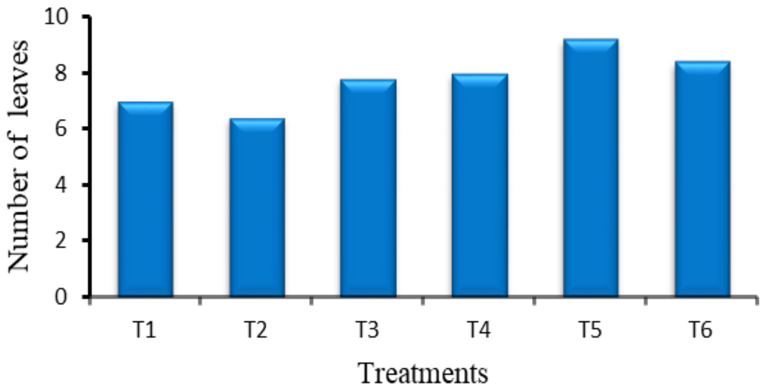

Figure 2. The effect of goat manure, molasses and 50% TSP application on the average number of beetroot leaves.

Leaf length

Statistically analyzed data revealed that there was a remarkable difference (P<0.0001) in the length of the 1st leaf of the plant among the treatments (Table 1). This ranged from 9.20 cm to 13.36 cm, whereas it was 8.90 cm – 10.30 cm for the length of the 2nd leaf. These lengths were higher in T5 compared to other treatments. The application of molasses may provide the plant nutrients probably potassium for the leaf growth. The result obtained in this study was in agreement with the findings of Shabala (2003) and Fromm (2010), who have mentioned that potassium serves a vital role for osmoregulation, cell expansion, stomatal movements and photosynthesis. In the other study, the increasing potassium fertilizer application resulted in decreased phosphorus (Baghour et al., 2001; Lin and Yeh, 2008) and Ca and Mg concentrations in leaves (Sabreen and Saiga, 2004; Lin and Yeh, 2008). The inadequate primary nutrient supply reduces photosynthesis, leaf production and plant growth (Zhao et al., 2005), which is an indication that the plant requires a balanced supply of plant nutrients for better leaf growth.

Table 1. The effect of goat manure, molasses and 50% TSP application on the average lengths of leaf and petiole of the beetroot plant.

Treatment	1st leaf length (cm)	2nd leaf length (cm)	Petiole length of the 1st leaf (cm)	Petiole length of the 2nd leaf (cm)
T1	11.50±0.59b	09.90±0.50	10.60±1.80ab	11.00±1.67ab
T2	09.20±0.70b	09.40±0.62	08.10±0.33b	08.60±1.12b
T3	09.50±0.74b	09.80±0.25	11.00±1.04ab	11.30±0.86ab
T4	11.00±0.88b	09.50±0.74	12.20±0.37ab	11.70±1.11ab
T5	13.36±0.42a	10.30±1.82	13.80±1.46a	12.10±0.84a
T6	10.50±0.94b	08.90±0.62	10.20±0.46ab	10.00±0.22ab
F test	P<0.0001	P>0.05	P<0.05	P<0.05

The value represents the mean ± standard error of replicates. Means followed by the same letters in each column are not significantly different according to the Tukey’s test at the 5% significance level.

Leaf petiole length

There was a substantial variation (P<0.05) in the petiole length of the beetroot plant among the treatments. Petiole lengths of the 1st leaf (13.80 cm) and the 2nd leaf (12.10 cm) were the longest in T5 compared to other treatments (Table 1). Potassium is identified as the dominant osmoticum (Shabala et al., 2000), and it is important for cell enlargement and stomatal function (Shabala, 2003). Plants make use of calcium ion for strengthening cell walls (Hepler, 2005). In addition to N, P and K nutrients, the application of goat manure also supplies Ca, Mg and other micronutrients to soil for plant growth as stated by Ojeniyi and Adegboyega (2003).

Leaf width

A significant difference ($P<0.001$) was observed in the average leaf width of the plant among the treatments. The higher value of 6.24 cm was attained in T5, and a lower value of 5.04 cm was noted in T6 (Table 2). Leaf width was considerably higher ($P<0.05$) in the T5 treatment than in other treatments except for T4. This finding was supported by the result of Shabala et al. (2000), who stated that potassium plays a role in cell enlargement and leaf expansion. The T6 treatment had a lower value of leaf width than T5. A high potassium concentration may cause a deficiency of calcium and magnesium (Nguyen et al., 2017). As a result of low calcium availability, a decrease of plant height, leaf area and plant growth was observed by Leal and Prado (2008).

Table 2. The effect of goat manure, molasses and 50% TSP application on the average leaf width and shoot weight of the beetroot plant.

Treatment	Leaf width (cm)	Fresh weight of shoot (g)	Dry weight of shoot (cm)
T1	5.08±0.12b	14.27±0.67abc	2.42±0.45ab
T2	5.20±0.15b	10.55±0.49c	1.62±0.40b
T3	5.28±0.13b	12.47±0.89bc	1.97±0.29b
T4	6.20±0.12a	16.55±0.91ab	2.72±0.40ab
T5	6.24±0.11a	17.55±0.37a	3.02±0.39a
T6	5.04±0.09b	16.77±0.95ab	2.79±0.07ab
F test	P<0.001	P<0.01	P<0.05

The value represents the mean ± standard error of replicates. Means followed by the same letters in each column are not significantly different according to the Tukey's test at the 5% significance level.

Shoot weight of the beetroot plant

Fresh and dry weights of the shoot (above-ground level plant part) per plant are given in Table 2. Significant differences in both fresh ($P<0.01$) and dry ($P<0.05$) weights of the shoot were observed among the treatments. The values of fresh (17.55 g) and dry (3.02 g) shoot weights obtained in T5 were higher than those in other treatments while lower values (10.55 g and 1.62 g respectively) were recorded in T2. The T1 treatment using inorganic fertilizers alone produced 14.27 g of fresh and 2.42g of dry shoot weights. A similar shoot weight was recorded between T1 and T2. It may be due to potassium availability to plants. Potassium performs significant roles in the physiological processes, such as photosynthesis, translocation of photoassimilates, transportation of water and nutrients, nutrient balance, etc., in plants (Marschner, 2012; Hasanuzzaman et al., 2018).

Chlorophyll content

There was a significant variation ($P<0.05$) in the chlorophyll content of leaves, as shown in Figure 3. The leaf chlorophyll content ranged from 35.40 (T2) to 45.17 (T5) and a notable difference ($P<0.05$) was observed between T2 and T5 treatments. This difference may be due to the required amount of nutrients received by plants. Chlorophyll is necessary for photosynthesis to produce essential carbohydrates as a food source for the plants (Hynninen and Leppakases, 2002). Guo et al. (2019) have stated that increased potassium supply interferes with the uptake of the other nutrients, particularly nitrogen and potassium uptake, and optimal potassium enhances the nutritional function of NO_3^- in wheat plants.

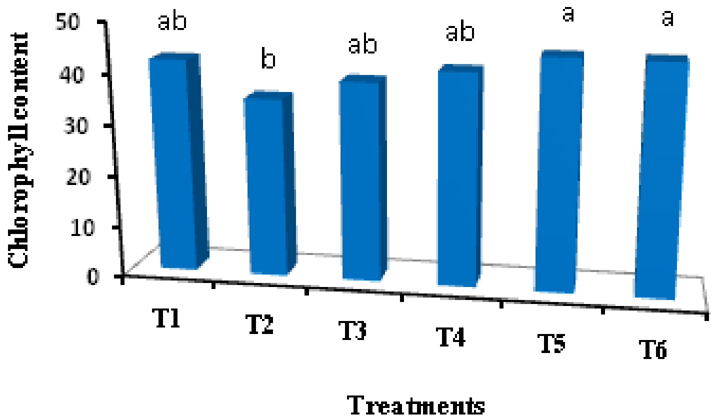

Figure 3. The effect of goat manure, molasses and 50% TSP application on the average chlorophyll content of beetroot leaves.

Diameter of the edible root

The diameter value of the edible root (beetroot) in each treatment is shown in Table 3. According to the statistical analysis, there was a considerable difference ($P<0.01$) in the diameter of beetroot among the treatments. A high average value (4.04 cm) of the root diameter was attained in T4 (10 t/ha of goat manure, 2 t/ha of sugar molasses and 50% TSP). This value, however, was statistically similar to those in T1 and T5 treatments.

The reason may be due to the sufficient amount of potassium supplied by molasses for increasing the diameter of the beetroot grown in sandy regosol soil. The potassium fertilizer application increased the total sugar in beetroot plants grown in sandy calcareous soil (Abdel-Motagally and Attia, 2009). In this study, T5 and T6 treatments showed lower values of the root diameter than the value obtained in T4. A higher rate of potassium provides the adverse effect on calcium (Leal and Prado, 2008), but calcium is very important for fundamental physiological functions in plant structure and signalling (Gilliham et al., 2011). Domingues et al. (2016) reported that the dry mass of the shoot and root was high in plants grown with high calcium concentrations.

Table 3. The effect of goat manure, molasses and 50% TSP application on the average diameter of beetroot (edible root).

Treatment	Diameter of beetroot (cm)	Fresh weight of edible root (g)	Fresh weight of plant (g)
T1	3.12±0.13ab	27.84±1.51c	42.12±1.94bc
T2	2.64±0.34b	22.29±0.64d	32.84±0.37d
T3	2.92±0.20b	27.04±0.77cd	39.52±1.29cd
T4	4.04±0.20a	37.28±1.36a	53.83±1.78a
T5	3.51±0.17ab	33.21±1.37ab	50.76±1.34a
T6	3.40±0.27ab	30.18±0.31bc	46.96±1.07ab
F test	P<0.01	P<0.0001	P<0.0001

The value represents the mean ± standard error of replicates. Means followed by the same letters in each column are not significantly different according to the Tukey's test at the 5% significance level.

Fresh weight of the edible root

The fresh weight of the edible root (beetroot) per plant is indicated in Table 3. There was a remarkable difference (P<0.0001) in the fresh weight of the beetroot among the treatments. The fresh weight of the root ranged from 22.29 g to 37.28 g. The combined application of 10 t/ha of goat manure, 2 t/ha of sugar molasses and 50% TSP significantly (P<0.05) had a higher value of beetroot than the other treatments except for T5. The lowest fresh weight was recorded in T2. Romheld and Kirkby (2010) mentioned the positive effect of the potassium fertilizer application on the yield of sugar beet. Mg deficient plants are less competent to translocate sucrose to the root via the phloem (Hermans et al., 2006; Farhat et al., 2016). Potassium nutrient accumulates more in roots than in the shoot of the beetroot plant (Granjeiro et al., 2007). Chen et al. (2018) reported that magnesium deficiency did not influence the dry weight of the shoot but reduced the dry weight of the root. The application of farmyard manure with reduced inorganic fertilizers improves soil fertility and crop yield (Seran, 2016).

Fresh weight of the beetroot plant

There was a significant variation (P<0.0001) in the total fresh weight of the plant among the treatments. The total fresh weight of the beetroot plant in each treatment is shown in Table 3. The maximum value of 53.83 g was recorded in T4, whereas a minimum value of 32.84 g was attained in T2. Abdel-Motagally and Attia (2009) stated that the fresh weight of beetroot was increased with increasing potassium rates. A similar result was reported by Chandraju et al. (2008), who noted that the application of molasses enhances the primary nutrient uptake and yield of leafy vegetables. In plants grown with a low ion level of magnesium, total biomass is lower than that of plants with sufficient magnesium ions (Cakmak and Kirkby, 2008), and potassium deficiency results in a severe reduction in photosynthetic CO_2 fixation and use of photosynthates (Cakmak, 2005). The application of goat manure with EM could give a higher yield of vegetable cowpea (Seran and Shahardeen, 2012).

Beetroot yield

Marketable root yield (g/m^2) and total crop yield (g/m^2) of beetroot are given in Figure 4 and Figure 5, respectively. According to the statistical analysis, there were remarkable differences ($P<0.0001$) in root yield and total crop yield among the treatments. The highest root yield (1241.51g) and total crop yield (1792.62 g) of beetroot were obtained in the T4 treatment. These values, however, were not different from T5.

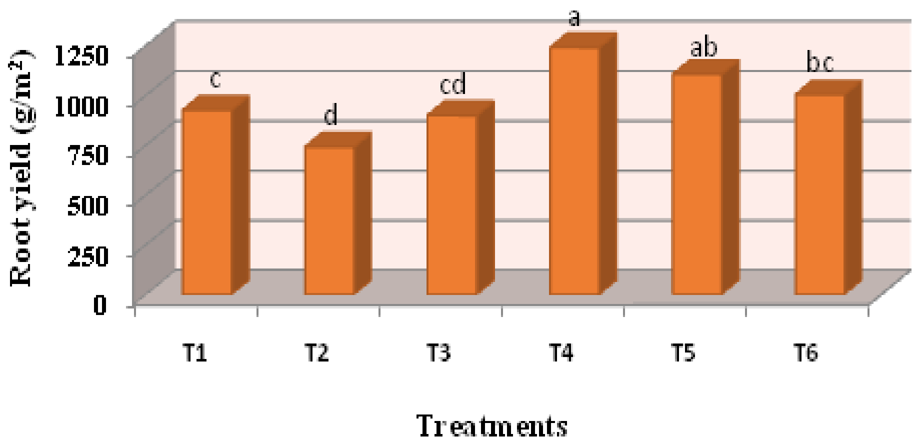

Figure 4. The effect of goat manure, molasses and 50% TSP application on the marketable root yield of beetroot crop.

Plants treated with T1 (control treatment) gave significantly lower values of the crop and root yields than plants treated with T4 and T5. This result supported the findings of Çakmak (2005) and Hermans et al. (2006), who have indicated that potassium and magnesium have important functions in photosynthesis and biomass distribution among the plant parts. Magro et al. (2015) have observed that the use of organic compost increases root production.

Plants treated with T1 (control treatment), T2 (10 t/ha of goat manure alone) and T3 (10 t/ha of goat manure, 1 t/ha and 50% TSP) gave significantly lower values ($P<0.05$) of root yield and crop yield than those in T4. Mohammadi and Brimvandi (2009) reported that the application of molasses increased available potassium and total nitrogen but reduced available phosphorus in soil. The excess potassium application may influence calcium and magnesium deficiency (Nguyen et al., 2017). In this study, goat manure, molasses and triple superphosphate provide essential macro and micronutrients for the growth and yield of beetroot in sandy regosol. Further, we suggest that naturally available phosphate fertilizer can be used in crop cultivation as a substitute for triple superphosphate (inorganic fertilizer) as stated by Sithamparam and Seran (2014).

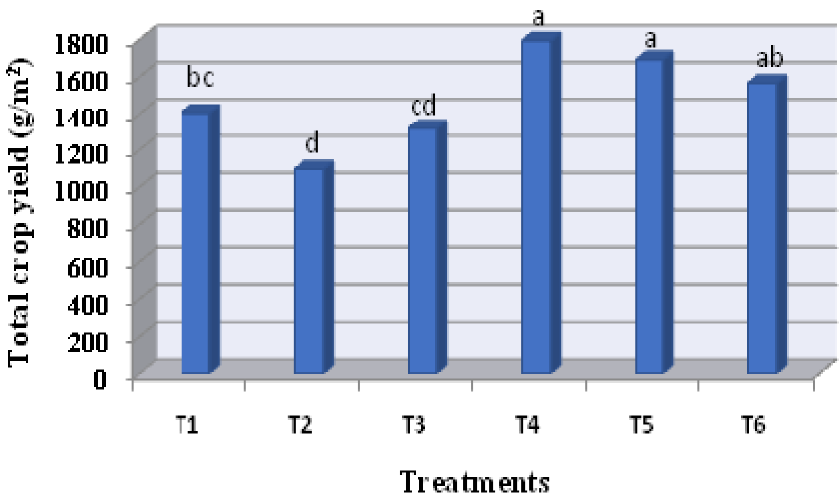

Figure 5. The effect of goat manure, molasses and 50% TSP application on the total yield of the beetroot crop.

Conclusion

The results revealed that the application of 10 t/ha of goat manure, 2–3 t/ha of sugarcane molasses and 50% TSP significantly increased marketable root yield and total crop yield of beetroot when compared to the recommended NPK inorganic fertilizers. Marketable root yield was high (1241.51g) in the T4 treatment (10 t/ha of goat manure, 2 t/ha of sugarcane molasses and 50% TSP) followed by T5 (10 t/ha of goat manure, 3 t/ha of sugarcane molasses and 50% TSP). The marketable root yield and total yield of the beetroot crop in T4 were increased by 33.8% and 27.8% respectively as compared to those in the control treatment. The result proves that goat manure combined with sugarcane molasses and TSP is a suitable source of nutrients for improving soil fertility and the yield of beetroot. This study concludes that the combined application of 10 t/ha of goat manure with 2 t/ha of sugarcane molasses and 50% TSP is more suitable for sandy regosol to obtain a high yield of beetroot than the recommended chemical fertilizer. Moreover, it can be suggested that organic or natural phosphorus resources can be used as a replacement for inorganic phosphorous fertilizer since organic manure is eco-friendly. A further study is necessary to evaluate the quality of beetroot.

References

Abdel-Motagally, F.M.F., & Attia, K.K. (2009). Response of sugar beet plants to nitrogen and potassium fertilization in sandy calcareous soil. *International Journal of Agriculture and Biology, 11* (6), 695-700.

Baghour, M., Sánchez, E., Ruiz, J.M., & Romero, L. (2001). Metabolism and efficiency of phosphorus utilization during senescence in pepper plants: Response to nitrogenous and potassium fertilization. *Journal of Plant Nutrition, 24* (11), 1731-1743.

Cakmak, I. (2005). The role of potassium in alleviating detrimental effects of abiotic stresses in plants. *Journal of Plant Nutrition and Soil Science, 168*, 521-530.

Cakmak, I., & Kirkby, E.A. (2008). Role of magnesium in carbon partitioning and alleviating photooxidative damage. *Physiologia Plantarum, 133*, 692-704.

Chandraju, S., Basavaraju, H.C., & Chidankumar, C.S. (2008). Investigation of impact of Irrigation of distillery on the nutrients of cabbage and mint leaf. *Indian Sugar, 39* (19), 15-28.

Chen, J.H. (2006). The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. In *Proceedings of International workshop on sustained management of the soil-rhizosphere system for efficient crop production and fertilizer use*. 16-20 October, 2006. Land Development Department Bangkok, Thailand. pp 1-11. Available from http://www.agnet.org/htmlarea_file/library/20110808103954/tb174.pdf

Chen, C.T., Lee, C.L., & Yeh, D.M. (2018). Effects of Nitrogen, Phosphorus, Potassium, Calcium, or Magnesium Deficiency on Growth and Photosynthesis of *Eustoma. HortScience*, *53* (6), 795-798.

De la Rosaa, O., Flores-Gallegosa, A.C., Muñíz-Marquezb, D., Nobrec, C., Contreras-Esquivela, J.C & Aguilar, C.N. (2019). Fructooligosaccharides production from agro-wastes as alternative low-cost source. *Trends in Food Science & Technology*, 91, 39-146.

Domingues, L.S., Ribeiro, N.D., Andriolo, J.L., Possobom, M.T.D.F., & Zemolin, A.E.M. (2016). Growth, grain yield and calcium, potassium and magnesium accumulation in common bean plants as related to calcium nutrition. *Acta Scientiarum Agronomy, 38* (2), 207-217.

Eghball, B., Ginting, D., & Gilley, J.E. (2004). Residual effects of manure and compost applications on corn production and soil properties. *Agronomy Journal*, *96* (2), 442-447.

Farhat, N., Elkhouni, A., Zorrig, W., Smaoui, A., Abdelly, C., & Rabhi, M. (2016). Effects of magnesium deficiency on photosynthesis and carbohydrate partitioning. *Acta physiologiae plantarum, 38*, 145.

Fromm, J. (2010). Wood formation of trees in relation to potassium and calcium nutrition. *Tree Physiology, 30* (9), 1140-1147.

Gholizadeh, A., Amin, M.S.M., Anuar, A.R., & Aimrun, W. (2009). Evaluation of SPAD chlorophyll meter in two different rice stages and its temporal variability. *European Journal of Scientific Research*, *37* (4), 591-598.

Gilliham, M., Dayod, M., Hocking, B.J., Xu, B., Conn, S.J., Kaiser, B.N., & Tyermann, S.D. (2011). Calcium delivery and storage in plant leaves: exploring the link with water flow. *Journal of Experimental Botany*, *62* (7), 2233-2250.

Granjeiro, L.C., Negreiros, M.Z., Souza, B.S., Azevêdo, P.E., Oliveira, S.L., & Medeiros, M.A. (2007). Accumulation and exportation of nutrients in beet crop. *Cienc Agrotec*, *31*, 267-273.

Guo, J., Jia, Y., Chen, H., Zhang, L., Yang, J., Zhang, L., Hu, X., Ye, X., Li, Y., & Zhou, Y. (2019). Growth, photosynthesis, and nutrient uptake in wheat are affected by differences in nitrogen levels and forms and potassium supply. *Scientific Reports, 9*, 1248. doi:10.1038/s41598-018-37838-3

Hasanuzzaman, M., Borhannuddin, Bhuyan, M.H.M., Kamrun, N.I.D., Hossain, M.S., Al Mahmud, J., Hossen, M.S., Masud A.A.C., Moumita, I.D., & Fujita, M. (2018). Potassium: A Vital Regulator of Plant Responses and Tolerance to Abiotic Stresses. *Agronomy 8*, 1-31.

Hepler, P. (2005). Calcium: a central regulator of plant growth and development. *The Plant Cell*, *17* (8), 2142-2155.

Hermans, C., Hammond, J.P., White, P.J., & Verbruggen, N. (2006). How do plants respond to nutrient shortage by biomass allocation?. *Trends Plant Science, 11* (12), 610-617.

Hynninen, P.H., & Leppakases, T.S. (2002). The functions of chlorophylls in photosynthesis: physiology and maintenance. *In: Encyclopedia of Life Support System*, *5,* 1-9. EOLSS: Oxford, UK.

Imthiyas, M.S.M., & Seran, T.H. (2017). Residual effect of goat manure and expert^{TM} fertilizer treated with proceeding crop of radish (*Raphanus sativus* L.) on succeeding crop of vegetable cowpea (*Vigna uniguiculata* L.). *Annals of Agricultural and Environmental Sciences, 2* (2), 1-5.

Jain, R., & Venkatasubramanian, P. (2017). Sugarcane Molasses–A Potential Dietary Supplement in the Management of Iron Deficiency Anemia. *Journal of dietary supplements, 14* (5), 589-598.

Kapadia, G.J., Tokuda, H., Konoshima, T., & Nishino, H. (1996). Chemoprevention of lung and skin cancer by Beta vulgaris (beet) root extract. *Cancer Letters, 100* (1-2), 211-214.

Leal, R.M., & Prado, R.D.M. (2008). Nutritional disorders in common bean due to deficiency of macronutrients, boron and zinc. *Brazilian Journal of Agricultural Sciences (Agrarian), 3* (4), 301-306.

Lin, C.Y., & Yeh, D.M. (2008). Potassium Nutrition Affects Leaf Growth, Anatomy, and Macro elements of Guzmania. *Hort Science, 43* (1), 146-148.

Magro, F.O., da Silva, E.G., Takata, W.H.S., Cardoso, A.I.I., Fernandes, D.M., & Evangelista, R.M. (2015). Organic compost and potassium top dressing fertilization on production and quality of beetroot. *Australian Journal of Crop Science*, *9* (10), 962-967.

Marschner, H. (2012). *Marschner's Mineral Nutrition of Higher Plants*, 3rd ed, Academic Press: London, UK, pp. 178-189.

Mohammadi, T.A., & Barimvandi, A.R. (2009). The effects of sugar cane molasses on calcareous soil chemical characteristics. *Pajouhesn-Va Sazandegi Winter*, *21* (4), 47-53. (81 In Agronomy and Horticulture).

Murmu, K., Swain, D.K., & Ghosh, B.C. (2013). Comparative assessment of conventional and organic nutrient management on crop growth and yield and soil fertility in tomato-sweet corn production system. *Australian Journal of Crop Science*, *7* (11), 1617-1626.

Nahla, T.K., Wisam, S.U., & Tariq, N.M. (2018). Antioxidant Activities of Beetroot (*Beta vulgaris* L.) Extracts. *Pakistan Journal of Nutrition, 17,* 500-505.

Nguyen, H.H., Maneepong, S., & Suraninpong, P. (2017). Effects of Potassium, Calcium, and Magnesium Ratios in Soil on Their Uptake and Fruit Quality of Pummelo. *Journal of Agricultural Science, 9* (12). 110-121.

Ojeniyi, S.O., & Adegboyega, A.A. (2003). Effect of combined use of urea and goat dung manure on celosia. *Nigeria Agriculture Journal*, *34*, 87-90.

Raveenthira, V., & Seran, T.H. (2020). Seed yield of *Abelmoschus esculentus* L. as influenced by the combined use of inorganic and organic fertilizers. *Research Journal of Agriculture and Forestry, 8* (1), 49-52.

Römheld, V., & Kirkby, E.A. (2010). Research on potassium in agriculture: needs and prospects. *Plant and Soil*, *335* (1-2), 155-180.

Sabreen, S., & Saiga, S. (2004). Potassium level suitable for screening high magnesium containing grass seedlings under solution culture. *Journal of plant nutrition*, *27* (6), 1015-1027.

Samavat, S., & Samavat, S. (2014). The effects of fulvic acid and sugar cane molasses on yield and qualities of tomato. *International Research Journal of Applied and Basic Sciences, 8* (3), 266-268.

Seran, T.H. (2016). Yield and yield components of *Arachis hypogaea* L. as influenced by NPK chemical fertilizers, farm yard manure and gypsum. *Bangladesh Journal of Scientific and Industrial Research*, *51* (4), 285-290.

Seran, T.H., & Shahardeen, R.N.M. (2012). A note on the performance of vegetable cowpea (*Vigna unguiculata*) seeds harvested from plants grown in animal manure with effective microorganisms (EM). *Sudan Journal of Agricultural Research*, *20,* 113-118.

Serio, F., Elia, A., Santamaria, P., Rodriguez, G.R., Conversa, G., Bianco, V.V., Fernandez, J.A., Martinez, P.F., & Castilla, N. (2001). Lettuce growth, yield and nitrate content as affected by electrical conductivity of nutrient solution. *Acta Horticulture 559* (2), 563-568.

Shabala, S., Babourina, O., & Newman, I. (2000). Ion-specific mechanisms of osmoregulation in bean mesophyll cells. *Journal of Experimental Botany, 51* (348), 1243-1253.

Shabala, S. (2003). Regulation of potassium transport in leaves: from molecular to tissue level. *Annals of Botany*, *92* (5), 627-634.

Shaibur, M.R., Shamim, A.H.M., & Kawai, S. (2008). Growth Response of Hydroponic Rice Seedlings at Elevated Concentrations of Potassium Chloride. *Agriculture and Rural Development, 6* (1&2), 43-53.

Sithamparam, P., & Seran, T.H. (2014). Root and shoot growth of soybean (*Glycine max*) as influenced by naturally available phosphous nutrition with manure. *Journal of Agriculture and Environment, 15*, 79-88.

Suthamathy, N., & Seran T.H. (2009). Effect of cow manure, coir dust and paddy husk ash on physical and chemical properties of potting media. *Proceedings of the 8th Annual Research Session, Eastern University, Sri Lanka*, pp 185-190.

Taiz, L., & Zeiger, E.M. (2006). *Plant Physiology*. fourth edition Sinauer Associates. Inc. Sunderland: pp 690

Takara, K., Ushijima, K., Wada, K., Iwasaki, H., & Yamashita, M. (2007). Phenolic compounds from sugarcane molasses possessing antibacterial activity against cariogenic bacteria. *Journal of Oleo Science, 56* (11), 611-614.

Ullah, M.F., & Khan, M.W. (2008). Food as medicine: Potential therapeutic tendencies of plant derived polyphenolic compounds. *Asian Pacific Journal of Cancer Prevention, 9* (2), 187-196.

Zhao, D., Reddy, K.R., Kakani, V.G., Read, J.J., & Koti, S. (2005). Nitrogen deficiency effects on plant growth, leaf photosynthesis, and hyperspectral reflectance properties of sorghum. *European Journal of Agronomy*, *22*, 391-403.

Received: June 12, 2020
Accepted: November 20, 2020

UTICAJ KOZJEG STAJNJAKA I MELASE ŠEĆERNE TRSKE NA RAST I PRINOS CVEKLE (*BETA VULGARIS* L)

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R e z i m e

Ogled je sproveden u sudovima kako bi se proučio uticaj kozjeg stajnjaka i melase šećerne trske na rast i prinos cvekle (*Beta vulgaris L.*) u peskovitom regosolu. Ogled je postavljen u potpuno slučajnom dizajnu (PSD) sa šest tretmana. Tretmani su uključivali neorgansko đubrivo (T1), 10 t/ha samo kozjeg stajnjaka (T2), a takođe 10 t/ha kozjeg stajnjaka i 50% trostrukog superfosfata (TSP) sa 1–4 t/ha melase šećerne trske (T3–T6). Rezultati su pokazali da su parametri rasta biljaka (dužina lista, dužina peteljki lista, širina lista, broj listova, sveža masa i suva masa listova) značajno varirali među tretmanima. Među tretmanima je postojala značajna razlika u prečniku cvekle. Značajne razlike ($P<0,05$) primećene su u svežoj masi cvekle i cele biljke u zavisnosti od tretmana. Prinos sveže masa korena i ukupni prinos cvekle po biljci povećani su kod tretmana sa 10 t/ha kozjeg stajnjaka, 2 t/ha melase šećerne trske i 50% TSP (T4) i 10 t/ha kozjeg stajnjaka, 3 t/ha melase šećerne trske i 50% TSP (T5) u poređenju sa kontrolnim tretmanom (T1). Ukupan prinos cvekle po m^2 iznosio je 1.792,62 g u tretmanu T4 i 1.402,68 g u tretmanu T1. Prinos korena cvekle povećan je u tretmanu T4 u poređenju sa tretmanom T5. Može se zaključiti da se 10 t/ha kozjeg stajnjaka sa 2 t/ha melase šećerne trske i 50% TSP može primeniti za dobijanje visokog prinosa cvekle u peskovitom regosolu.

Ključne reči: cvekla, kozji stajnjak, melasa, prinos.

Primljeno: 12. juna 2020.
Odobreno: 20. novembra 2020.

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