The growth performance of sweet corn under the influence of animal manure, NPK and soil type

E.T. Sebetha* and L.V. Mashele

Food Security and Safety Niche Area, Faculty of Agriculture Science and Technology. North-West University, Mafikeng Campus, Private Bag x 2046, Mmabatho 2735.  
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ABSTRACT
The experiment was conducted to investigate the influence of animal manures, NPK and soil type on growth performance of sweet corn. The study consisted of five different fertilizers (poultry manure, goat manure, cattle manure, NPK and control) and two soil types (sand clay loam and sandy loam). The study was a 5 x 2 factorial experiment in a complete randomized design with three replications and conducted during autumn and spring seasons of 2018. Measured growth parameters were number of leaves per plant, plant height, leaf area, stem diameter and chlorophyll content. Sweet corn fertilized with goat manure had significantly higher number of leaves per plant (9.17), higher leaf area (450 cm²) and stem diameter (2.18 cm). Sweet corn planted under sand clay loam soil had significantly taller plant height, higher number of leaves per plant, leaf area and stem diameter. Sweet corn showed better growth performance when planted under animal manures and sand clay loam soil.

Key words: Cattle manure, Goat manure, Poultry manure, Soil type.

INTRODUCTION

Sweet corn (Zea mays. saccharata) is an annual cereal grain, which originates from South America. Sweet corn is referred to as a versatile crop because it can grow under various climatic zones. In South Africa the conditions vary from moderate to cool climates (Booysen et al., 1984). It is a summer crop and requires warm and needs at least temperatures ranging from 18-20ºC for germination of the seed. To obtain optimum growth, sweet corn needs temperatures ranging from 24-30ºC, with soil moisture of 60% to 70% field capacity and need about 80-120 frost free days, from sowing to harvest (Smith, 2006). Sweet corn requires rainfall distribution of 500 to 800mm during the growing season. Insufficient supply of water will result in slow growth because sweet corn is a crop that requires large amount of water for optimum growth (Payero et al., 2006). Sweet corn performs well under a variety of soil types but requires rich, moist and well drained loam to sandy loam soils for optimum growth. The areas with low medium rainfall on heavy textured soils results in reduced yields due to the soil being high in clay content resulting on the sweet corn plant being unable to extract water and other nutrients (Smith, 2006). Drier areas with sandy loam soils are ideal for growing sweet corn as the soil is loose and plants roots are able to penetrate deep into the soil and water infiltrates easily into the soil.

The application of inorganic fertilizer usually improves crop yields and plant growth on sweet corn. Inorganic fertilizers such as nitrogen, phosphorus and potassium are crucial for plant development, as they stimulate early growth and increase plant growth (Niehues, 2004). Inorganic fertilizer containing NPK improves sweet corn yield and also benefits the soil with adequate phosphorus and potassium (Buah et al., 1999). Nitrogen and phosphorus are a major limiting factor in sweet corn because nitrogen hasten seedling growth of sweet corn and phosphorus increases germination and influences root system and root formation during vegetative growth stage (Ciampitti and Vyn, 2010).

The role of animal manure in maintaining organic matter and raising the growth of cereal crops had been recognized in most agro-ecological zones (Miracle, 2009). Animal manures are rich in macro and micro nutrients, which are highly required for the growth development of sweet corn. The application of animal manure in sweet corn improves seed germination by increasing germination rate (Raramurthy and Shivashankar, 1996). During growth periods of sweet corn, animal manures improves the growth of tassels and also produces large ears. It also increases grain filling, resulting in grains with high protein content (Silva et al., 2004; Shah et al., 2009). Sweet corn is mostly grown through the use of inorganic fertilizer in most countries around the world, and the use of animal manures is not preferred by many farmers. Therefore, this results in resource poor farmers having little knowledge on the usage of animal manure. Farmers grow sweet corn on soil that has low water...
and nutrient holding capacity. Therefore, the objectives of the study were to determine the influence of animal manures, NPK and soil type on growth performance of sweet corn.

### MATERIALS AND METHODS

The experiment was conducted inside the greenhouse at the North-West University Agriculture farm, Molelwane during autumn and spring seasons of 2018. The farm is located (25º48’S, 45º38’E), which is situated at the North West province in Mafikeng and lies in a semi-arid region. The site area received mean annual rainfall of 571mm during summer seasons and had summer temperatures, which ranged between 22 and 34°C. The soil type found at the farm were classified as the Hutton series according to the South African soil classification and had a red sandy loam texture (Kasirivu et al., 2011; Molope, 1987).

The experimental design was a 5×2 factorial experimental design fitted in a complete randomized design (CRD). The five types of fertilizers used were poultry manure, cattle manure, goat manure, NPK fertilizer and the control. The two soil types used were sandy clay loam and sandy loam. The treatments were replicated three times and each replicate had 10 treatment combination factors and the experiment had 30 pots in total.

The soil was collected in two different locations before planting. Both locations are situated in the North-West province. The soil was collected at the North-West University Mafikeng campus and at the Taung Research station. The soil collected from both locations was analysed for physical properties and chemical properties. The physical properties analysed were soil texture using the texture hydrometer method and the chemical properties analysed were soil pH using the saturated water paste method, nitrogen content using the K\textsubscript{2}SO\textsubscript{4} method, phosphorus content using the Bray 1 method. The laboratory analyses for soil texture, chemical and physical properties before planting are as indicated on Table 1.

The experiment had 30 pots in total and 5 kg of soil was filled in each pot. In each pot, 3 seeds were sown. Urea and superphosphate fertilizer were applied at planting at 5cm depth, below the seeds. The seeds on the sandy clay loam and sandy loam were sown at the depth of 3 cm. After seed germination two plants remained in each pot and the other plants were thinned.

Thinning was done after emergence to maintain two plant per pot. Irrigation was done 3 times a week and a volume of 600 ml of water was applied per pot. Weeding was done manually by hand, to control weeds in the pots.

Three different types of animal manures, poultry manure, cattle manure and goat manure were applied in soils two weeks before planting at 15 tons/ha. The amount of animal manure applied was calculated and reduce to grams, which was then applied in each pot. Two types of inorganic fertilizer, urea and superphosphate were applied at planting. Nitrogen was applied at 120 kg/ha and phosphorus was applied at 60 kg/ha. Data was collected before tasselling at 46 DAP and after tasselling at 81 DAP during autumn and spring. The laboratory results of different animal manures for chemical properties are as indicated in Table 2.

The leaves were counted from each plant per pot in each treatment combination factor. Plant height was recorded using a measuring tape and was recorded in cm, measuring from the stem base to the tip of the leaf of the plant. Leaf area was recorded using a measuring tape, measuring the length and breadth on the leaf of each plant per pot. Stem diameter was recorded using the Vernier caliper, measuring at the base of the sweet corn stalk stem of the plant. Chlorophyll content was recorded using a hand held chlorophyll meter and the chlorophyll content was measured in the middle of the leaf.

Data collected was subjected to the analysis of variance (ANOVA) to compare the treatment means and analysis of variance was done using the Gen-Stat and the means of significantly difference variables were separated using the least significant difference (LSD) test.

### Table 1: The soil texture, physical and chemical properties from different locations in North-West and the methods used for analysis.

| Physical properties | Tauung | Mafikeng | Method                  |
|---------------------|--------|----------|-------------------------|
| % Sand              | 88%    | 72%      | Texture-Hydrometer       |
| % Silt              | 3%     | 20%      | Texture-Hydrometer       |
| % Clay              | 9%     | 8%       | Texture-Hydrometer       |
| Chemical properties |        |          |                         |
| pH water            | 6.36   | 8.29     | Saturated water paste    |
| Phosphorus          | 4      | 4        | Bray 1 Method            |
| Nitrogen: N-NO\textsubscript{3} | 2.95 | 0.86 | K\textsubscript{2}SO\textsubscript{4} |
| N-NH\textsubscript{4} | 0.60  | 1.20     |                         |
| Soil texture        | Sandy loam | Sandy clay loam | Textural triangle         |

### Table 2: Animal manures chemical properties.

| Description   | % N | % P | % K |
|---------------|-----|-----|-----|
| Poultry manure| 2.95| 1.35| 1.77|
| Goat manure   | 1.71| 0.61| 0.39|
| Cattle manure | 1.69| 0.47| 2.16|
RESULTS AND DISCUSSION

Effect of animal manure, NPK and soil type on plant height: Fertilizer type had significant effect (P≤0.05) on sweet corn plant height at 46 and 81 DAP during autumn and spring as indicated in Table 3. During autumn, sweet corn fertilized with NPK and cattle manure had taller plant height of 98.0 and 129.0 cm at 46 and 81 DAP respectively. During spring, sweet corn fertilized with NPK and cattle manure had significantly taller plant height of 71.1 and 128.0 cm at 46 and 81 DAP respectively. Soil type had significant effect (P≤0.05) on sweet corn plant height at 46 and 81 DAP during autumn. Sweet corn planted under sandy clay loam soil had significantly taller plant height of 83.2 and 105.6 cm at 46 and 81 DAP respectively during autumn. During spring, soil type had significant effect (P≤0.05) on sweet corn plant height at 46 DAP. Sweet corn planted under sandy clay loam soil had significantly taller plant height of 59.9 cm at 46 DAP. Interaction of fertilizer type × soil type had significant effect (P≤0.05) on sweet corn plant height at 46 DAP during autumn.

Table 3: The effect of fertilizer and soil types on sweet corn plant height during autumn and spring seasons.

| Treatment                  | Autumn | Spring |
|----------------------------|--------|--------|
|                           | 46 DAP | 81 DAP |
| Fertilizer type            |        |        |
| Poultry                    | 61.1   | 79.7   |
| Cattle                     | 85.0   | 129.0  |
| Goat                       | 92.6   | 120.7  |
| NPK                        | 98.0   | 107.8  |
| Control                    | 47.7   | 55.6   |
| LSD _0.05                  | 14.31  | 15.03  |
| Soil type                  |        |        |
| Sandy clay loam            | 83.2   | 105.6  |
| Sandy loam                 | 70.5   | 91.6   |
| LSD _0.05                  | 9.05   | 9.50   |

DAP= Days after planting, LSD= Least significant difference.

Effect of animal manure, NPK and soil type on number of leaves per plant: Fertilizer type had significant effect (P≤0.05) on sweet number of leaves at 46 DAP during autumn as indicated in Table 4. During autumn, sweet corn fertilized with goat manure had significantly higher number of leaves of 9.17 at 46 DAP. During spring, fertilizer type had significant effect (P≤0.05) on sweet corn number of leaves at 46 DAP. Sweet corn fertilized with cattle manure had significantly higher number of leaves of 9.00 at 46 DAP during spring.

Table 4: The effect of fertilizer and soil types on sweet corn number of leaves during autumn and spring seasons.

| Treatment                  | Autumn | Spring |
|----------------------------|--------|--------|
|                           | 46 DAP | 81 DAP |
| Fertilizer type            |        |        |
| Poultry                    | 7.17   | 7.17   |
| Cattle                     | 9.00   | 6.50   |
| Goat                       | 9.17   | 6.50   |
| NPK                        | 8.67   | 6.67   |
| Control                    | 6.83   | 5.97   |
| LSD _0.05                  | 1.68   | 0.97   |
| Soil type                  |        |        |
| Sandy clay loam            | 9.00   | 6.20   |
| Sandy loam                 | 7.33   | 6.93   |
| LSD _0.05                  | 1.06   | 0.62   |

DAP= Days after planting, LSD= Least significant difference.

Effect of animal manure, NPK and soil type on leaf area: Fertilizer type had significant effect (P≤0.05) on sweet corn leaf area at 46 and 81 DAP during autumn and spring as indicated in Table 5. Sweet corn fertilized with goat manure and NPK had significantly higher leaf area of 450 and 587 cm² at 46 and 81 DAP respectively during autumn. During spring, sweet corn fertilized with NPK and cattle manure had significantly higher leaf area of 297 and 591 cm² at 46 and 814 DAP respectively.

Table 5: The effect of fertilizer and soil types on sweet corn leaf area during autumn and spring seasons.

| Treatment                  | Autumn | Spring |
|----------------------------|--------|--------|
|                           | 46 DAP | 81 DAP |
| Fertilizer type            |        |        |
| Poultry                    | 228    | 323    |
| Cattle                     | 396    | 568    |
| Goat                       | 450    | 482    |
| NPK                        | 436    | 587    |
| Control                    | 136    | 159    |
| LSD _0.05                  | 134.3  | 109.5  |
| Soil type                  |        |        |
| Sandy clay loam            | 372    | 450    |
| Sandy loam                 | 287    | 398    |
| LSD _0.05                  | 85.0   | 69.2   |

DAP= Days after planting, LSD= Least significant difference.

Effect of animal manure, NPK and soil type on stem diameter: Fertilizer type had significant effect (P≤0.05) on sweet corn stem diameter at 46 and 81 DAP during autumn and spring as indicated in Table 6. Sweet corn fertilized with NPK and cattle manure had significantly higher stem diameter of 9.00 at 46 DAP during autumn.

Table 6: The effect of fertilizer and soil types on sweet corn stem diameter during autumn and spring seasons.

| Treatment                  | Autumn | Spring |
|----------------------------|--------|--------|
|                           | 46 DAP | 81 DAP |
| Fertilizer type            |        |        |
| Poultry                    | 6.93   | 4.47   |
| Cattle                     | 8.67   | 5.87   |
| Goat                       | 9.00   | 6.50   |
| NPK                        | 98.0   | 107.8  |
| Control                    | 47.7   | 55.6   |
| LSD _0.05                  | 14.31  | 15.03  |
| LSD _0.05                  | 1.06   | 0.62   |

DAP= Days after planting, LSD= Least significant difference.
Table 6: The effect of fertilizer and soil types on sweet corn stem diameter during autumn and spring seasons.

| Treatment factors | Autumn  | Spring  |
|-------------------|---------|---------|
|                   | 46 DAP  | 81 DAP  | 46 DAP  | 81 DAP  |
| Fertilizer type   |         |         |         |         |
| Poultry           | 1.52    | 2.00    | 1.37    | 2.000   |
| Cattle            | 1.98    | 1.88    | 1.67    | 4.467   |
| Goat              | 2.18    | 1.88    | 1.75    | 2.250   |
| NPK               | 2.00    | 1.67    | 1.87    | 2.083   |
| Control           | 1.05    | 1.15    | 1.02    | 1.467   |
| LSD (t, 0.05)     | 0.41    | 0.38    | 0.35    | 0.30    |
| Soil type         |         |         |         |         |
| Sandy clay loam   | 1.88    | 1.69    | 1.65    | 2.15    |
| Sandy loam        | 1.61    | 1.75    | 1.42    | 1.96    |
| LSD (t, 0.05)     | 0.26    | 0.24    | 0.22    | 0.19    |

DAP= Days after planting, LSD= Least significant difference.

Table 7: The effect of fertilizer and soil types on sweet corn chlorophyll content during autumn and spring seasons.

| Treatment factors | Autumn  | Spring  |
|-------------------|---------|---------|
|                   | 46 DAP  | 81 DAP  | 46 DAP  | 81 DAP  |
| Fertilizer type   |         |         |         |         |
| Poultry           | 16.1    | 24.0    | 33.1    | 24.7    |
| Cattle            | 13.3    | 10.9    | 7.3     | 12.7    |
| Goat              | 25.2    | 20.7    | 8.1     | 28.4    |
| NPK               | 26.1    | 3.6     | 6.0     | 6.0     |
| Control           | 5.4     | 5.9     | 3.8     | 6.3     |
| LSD (t, 0.05)     | 21.62   | 12.55   | 11.10   | 8.78    |
| Soil type         |         |         |         |         |
| Sandy clay loam   | 16.4    | 15.9    | 9.7     | 17.6    |
| Sandy loam        | 18.1    | 10.2    | 13.6    | 13.7    |
| LSD (t, 0.05)     | 13.67   | 7.93    | 7.02    | 5.55    |

DAP= Days after planting, LSD= Least significant difference.

goat and poultry manure had significantly higher stem diameter of 2.18 and 2.00 cm at 46 and 81 DAP respectively during autumn. During spring, sweet corn fertilized with NPK and cattle manure had significantly higher stem diameter of 1.87 and 4.47 cm at 46 and 81 DAP respectively.

Soil type had significant effect (P≤0.05) on sweet corn stem diameter at 46 DAP during autumn. Sweet corn planted under sandy clay loam soil had significantly higher stem diameter of 1.88 cm at 46 DAP during autumn. During spring, soil type had significant effect (P≤0.05) on sweet corn stem diameter at 46 and 81 DAP. Sweet corn planted under sandy clay loam soil had significantly higher stem diameter of 1.65 and 2.15 cm. Interaction of fertilizer type × soil type had significant effect (P≤0.05) on sweet corn stem diameter at 81 DAP during spring.

Effect of animal manure, NPK and soil type on leaf chlorophyll content: Fertilizer type had significant effect (P≤0.05) on sweet corn chlorophyll content at 81 DAP during autumn as indicated in Table 7. Sweet corn fertilized with poultry manure had significantly higher chlorophyll content of 24.0 at 81 DAP during autumn. During spring, fertilizer type also had significant effect (P≤0.05) on sweet corn chlorophyll content at 46 and 81 DAP. Sweet corn fertilized with poultry and goat had significantly higher chlorophyll content of 33.1 and 28.4 at 41 and 81 DAP respectively during spring. Soil type had no significant effect (P≥0.05) on sweet corn chlorophyll content at 46 and 81 DAP during autumn and spring.

In this study, cattle manure resulted in taller plant height as compared to other animal manures. The taller plant height under cattle manure agreed with similar findings by Amos et al. (2015) who reported that application of 15 t/ha of cow dung gave the tallest plant height, which was an increase of about 24% compared with no treatment plots. Higher leaf area was recorded under cattle and goat manure in this study. This result corroborated the findings by Barsukov (1991) who reported that application of cattle manure and compost increased leaf area of maize plant by more than 26% compared with the control.

Stem diameter was found to be higher under poultry and goat manures. This might have been attributed to the chemical composition of the manures. This observation corroborated the findings by Uwah et al. (2014) who reported that both poultry and goat manures improved chemical properties of the soil and enhanced the agronomic performance of sweet maize. Sweet corn leaf chlorophyll content was found to be higher under poultry and goat manures in this study. This also might have been attributed to the chemical composition of both manures. This observation agreed with findings by Hameed et al. (2017) who reported that chlorophyll content were much higher in plant grown with organic manures, especially poultry and sheep manure treatments as compared with other treatments. The higher performance of sweet corn growth parameters under manures agreed with findings by Meena et al. (2008) who reported that farm yard manure significantly increased available N and organic matter in the soil, which lead to higher crop performance.

The growth parameters of sweet corn such as plant height, leaf area and stem diameter were higher under NPK treatment in this study. This result corroborated the findings by Law-Ogbomo and Law-Ogbomo (2009) who reported that NPK fertilizer applications significantly increased plant height, leaf area, dry matter accumulation and yield. The result also agreed with the findings by Dadarwal et al. (2009) who reported that the application of chemical fertilizer may assist in obtaining production of baby corn.

In this study, sweet corn planted under sandy clay loam performed significantly higher with taller plant height, high number of leaves, leaf area and stem diameter. This higher performance under sandy clay loam might have attributed to water holding capacity of the soil, which also retain nutrients for sweet corn. This observation corroborated...
the findings by Gangwar et al. (2006) who reported that sandy clay loam soil had water and nutrients holding capacity as a result of little percentage of clay. The result also agreed with findings by Ravankar et al. (2004) who reported that soil properties reflected higher yield in cereal crops such as sorghum and wheat.

**CONCLUSION**

The use of animal manures and soil type has significant role on the growth and yield performance of sweet corn. Sweet corn showed better growth performance when planted under animal manures and sandy clay loam soil.

**REFERENCES**

Amos, H., Voncir, N., Fagam, A.S., Garba, A. (2015). Effect of cattle manure on the growth and yield performance of vegetable maize (Zea mays Saccharata) varieties under irrigation. Scholars Journal of Agriculture and Veterinary Sciences. 2 (4A): 319-323.

Barsukov, S.S. (1991). Effect of organic and mineral fertilizers on yield of maize grown according to cereal technology. Agrokhimiya. 12: 43-48.

Booysen, C.R., Booysen, D.E., Booysen, J.H. (1984). Agricultural Science Standard 6 & 7. Kenwyn. Juta & Co Ltd. pp. 106.

Buah, S.J.S., Politio, T.A., Kilorn, R. (1999). No-tillage corn hybrids response to starter fertilizer. Journal of Production Agriculture. 12: 676-680.

Ciampitti, I.A. and Vyn, T.J. (2010). A comprehensive study of plant density consequences on nitrogen uptake dynamics of maize plants from vegetative to reproductive stages. Field Crops Research. 121 (1): 2-18.

Dadarwal, R.S., Jain, N.K., Singh, D. (2009). Integrated nutrient management in baby corn (Zea mays). Indian Journal of Agricultural Science. 79: 1023-1025.

Gangwar, K.S., Singh, K.K., Sharma, S.K., Tomar, O.K. (2006). Alternative tillage and crop residue management in wheat after rice in sandy loam soils of Indo-Gengetic plains. Soil Tillage Research. 88: 242-252.

Hameed, M.A.W., Khalaf, N.H., Farhan, H.N. (2017). The impact of several animal manure types in comparison with urea on growth and yield of maize (Zea mays L.). Euphrates Journal of Agriculture Science. 9 (2): 28-39.

Kasirivu, J., Materechera, S., Dire, M. (2011). Composting ruminant animal manure reduces emergence and species diversity of weed seedlings in a semi-arid environment of South Africa. South African Journal of Plant and Soil. 28: 228-235.

Law-Ogbomo, K.E. and Law-Ogbomo, J.E. (2009). The performance of Zea mays as influenced by NPK fertilizer application. Notulae Scientiae Biologicae. 1 (1): 59-62.

Meena, N.R., Meena, M.K., Sharma, K.K., Meena, M.D. (2018). Effect of zinc enriched farm yard manures on yield of mung bean and physico-chemical properties of soil. Legume Research. 41: 734-739.

Miracle, M.P. (2009). The introduction and spread of maize in Africa. The Journal of African History. 36: 39-55.

Molopo, M. (1987). Common Soils in the Molopo District. Tikilogo. 1: 65-76.

Niehues, B.J., Lamond, R.E., Godsey, C.B., Olsen, C.J. (2004). Starter nitrogen fertilizer management for continuous no-till corn production. Agronomy Journal. 96: 1412-1418.

Payero, J.O., Melvin, S.R., Irnak, S., Tarkelson, D. (2006). Yield response of corn to deficit irrigation in a semi-arid climate. Agricultural Water Management. 84: 101-112.

Ramamurthy, V. and Shivashankar, K. (1996). Residual effect of organic matter and phosphorus on growth, yield and quality of maize (Zea mays). Indian Journal of Agronomy. 41: 247-251.

Ravankar, H.N., Pothare, S., Rathod, P.K., Sarap, P.A. (2004). Soil properties and yield of sorghum-wheat sequence as affected by long term fertilization. Indian Journal of Agricultural Research. 38: 143-146.

Shah, S.T.H., Zamir, M.S.I., Waseem, M., Ali, A., Tahir, M., Khalid, W.B. (2009). Growth and yield response of maize (Zea mays L.) to organic and inorganic sources of nitrogen. Pakistani Journal of Life Sciences. 7: 108-111.

Silva, J., Silva, P.S.L., Oliveira, M., Silva, K.M.M. (2004). Effects of cattle manure on the production of green ears and corn grain. Brazilian Horticulture. 22: 326-331.

Smith, B. (2006). The Farming Handbook. Scottsville. University of KwaZulu-Natal Press. pp.276.

Uwah, D.F., Undie, U.L., John, N.M. (2014). Comparative evaluation of animal manures on soil properties, growth and yield of sweet maize (Zea mays L. saccharata Strut.). Journal of Agriculture and Environmental Sciences. 3 (2): 315-331.