
*Asian Plant Research Journal*

*7(4): 18-28, 2021; Article no.APRJ.67600*
*ISSN: 2581-9992*

# Growth and Yield Response of Groundnut (*Arachis hypogea* L.) to Inorganic Fertilisers at Luyengo, Middleveld of Eswatini

**Ziyanda Precious Mavimbela[1], Mzwandile Mabuza[1] and Tamado Tana[1*]**

*[1]Department of Crop Production, Faculty of Agriculture, University of Eswatini, P.O. Luyengo, M 205, Eswatini.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. Author ZPM managed the experiment and collected data. Author MM designed the study and prepared the protocol. Author TT analyzed the data and prepared the manuscript. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/APRJ/2021/v7i430161
Editor(s):
(1) Dr. Nesreen Houssien Abou- Baker, National Research Centre, Egypt.
Reviewers:
(1) Gerhard Moitzi, University of Natural Resources and Life Sciences, Austria.
(2) Albert Berdjour, International Institute of Tropical Agriculture (IITA), Ghana.
Complete Peer review History: http://www.sdiarticle4.com/review-history/67600

***Original Research Article***

***Received 12 February 2021***
***Accepted 18 April 2021***
***Published 07 May 2021***

## ABSTRACT

Groundnut is an important food and cash crop for smallholder farmers in Eswatini. However, its yield is very low partly due to poor soil fertility particularly calcium and phosphorus deficiencies associated with soil acidity. Thus, a field experiment was conducted to determine the effects of different inorganic fertiliser types on growth and yield of groundnut. The treatments were: a control with no fertiliser, [2:3:2 (22) at 300 kg ha$^{-1}$], single superphosphate (100 kg ha$^{-1}$), calcium nitrate (120 kg ha$^{-1}$) and a combination of calcium nitrate (120 kg ha$^{-1}$) and single superphosphate (100 kg ha$^{-1}$). A randomised complete block design (RCBD) with three replications was used. Results showed highly significant ($p<0.01$) differences among the fertiliser types on most of the growth parameters recorded. At 90% flowering, significantly highest number of leaves per plant (48.3), the tallest plant (42.17 cm), the highest canopy width (41.47 cm), the highest number of branches per plant (6.57) and plant dry biomass per plant (20.6 g) were recorded for treatments with calcium nitrate followed by the application of combination of calcium nitrate and single superphosphate. Similarly, most of the yield components and yield were significantly ($p<0.05$) affected by the fertiliser types. Significantly highest numbers of total pods per plant (28.8), mature pods per plant (26.9), dry

**Corresponding author: E-mail: tamado@uniswa.sz;*

pod yield (950.6 kg $ha^{-1}$), hundred seed mass (82.8 g), shelling percentage (70.6) and seed yield (671.6 kg $ha^{-1}$) were recorded from a combination of calcium nitrate and single superphosphate fertiliser. Thus, combined application of 120 kg $ha^{-1}$ calcium nitrate and 100 kg $ha^{-1}$ single superphosphate fertilisers can be used to increase the productivity of groundnut in the study area.

*Keywords: Calcium nitrate; 2:2:3 (22); groundnut; pod yield; single superphosphate.*

## 1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a self-pollinating, annual herbaceous legume crop [1]. It originated in South America and was subsequently taken to Africa, Europe and Asia. Its diversity has expanded throughout the tropical and warm temperate regions of the world and is now the most widely cultivated species of the genus *Arachis.* Two main types of groundnut are grown commercially; the first one grows upright with an erect central stem and vertical branches, and the other recumbent with numerous creeping laterals [2].

Groundnut is grown on 29.7 million hectares in the world, with a total production of 50.9 million tonnes in over 100 countries worldwide [3]. It has a huge potential to alleviating the protein nutrition problems in the developing countries of the world. It is an important food, feed, fertilizer, oil and fuel crop. Groundnut kernels are rich in protein and vitamins and can be eaten raw, roasted, fried, sweetened or boiled. For people in many developing countries, groundnut is the principal source of digestible protein (25 to 34%), cooking oil (44 to 56%), and vitamins like thiamine, riboflavin, and niacin [4]. The haulms are nutrition animal feed, and the shells can be used as fuel. Being a leguminous crop, it can fix atmospheric nitrogen in soils through root nodule bacteria and thus improves soil fertility [5]. Grain legumes like groundnut have been reported to provide an equivalent of 60 kg N $ha^{-1}$ to subsequent non-legume crop [6]. It grows well on light sandy loam soils which are not suitable for most of the other crops.

In Eswatini, groundnut is an important food and cash crop for smallholder farmers and its cultivation is confined to Eswatini Nation Land with an area harvested of 1925 ha and production of 741 tonnes in 2018 [3]. However, the yield of groundnut in Eswatini is very low (384.9 kg $ha^{-1}$) as compared to African average yield of 995.5 kg $ha^{-1}$ and world average yield of 1713.3 kg $ha^{-1}$ in 2018 [3]. Declining soil fertility, particularly calcium and phosphorus deficiencies associated with soil acidity, has been implicated as major possible cause of the low yield in groundnut.

Calcium is one of the less mobile nutrients in plants. In groundnut, there is little translocation from the main plant parts into the forming pods [7]. The seed develops via nutrients it gathers directly from the soil rather than those translocated from roots to shoots and back to the seeds [8]. This exceptional aspect has guided the applications of nutrients, especially calcium, for higher yield, quality and seed germination for groundnut. Calcium must be added to slightly acidic soils to correct pH value and improve the quality of the seed. Calcium deficiency leads to a high percentage of aborted seeds (empty pods or "pops") and improperly filled pods [9]. Thus, to get good yield of groundnut, adequate amounts of calcium should be present in the soil from the early flowering stage up to pod filling [10]. Kamara et al. [11] reported significantly higher number of filled pods, shelling percentage and hundred seed weight and higher pod yield with the application of 100 kg Ca $ha^{-1}$ than the control.

Phosphorus is another important nutrient for legumes in particular [12]. It is a key constituent of adenosine triphosphate (ATP) in plants and also plays various roles in seed formation. Absorption and reduction of nitrate is an energy consuming process and the energy is supplied by ATP. Phosphorus is needed for good seed formation. It also promotes root growth, enhances nutrient and water use efficiency and increases yield. The requirement of phosphorus in nodulating legumes is higher compared to non-nodulating crops as it plays a significant role in nodule formation and fixation of atmospheric nitrogen [13]. Phosphorus is needed in relatively large amounts by legumes for growth and has been reported to promote growth and yield, nodule number and nodule mass in different legumes [14]. Intodia et al. [15] reported that application of 60 kg $P_2O_5$ significantly increased number of pods per plant, shelling percentage, pod yield, haulm yield and oil yield of groundnut.

Most agricultural soils in Middleveld of Eswatini are acidic and as the result there is less availability of nutrients such as phosphorus and calcium [16]. Even though the groundnut crop is in demand, most smallholder farmers still lack some knowledge as to which fertiliser to use to increase yields. While some growers apply 2:3:2 (22) fertilizer, some do not add fertiliser at all.

Thus, this study was conducted to determine the effects of selected inorganic fertilisers on growth, yield components and yield of groundnut.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The experiment was conducted at the Crop Production Department Experimental Farm, University of Eswatini, Luyengo Campus during the 2019/2020 cropping season. The site is located in the Middleveld agro-ecological zone of Eswatini, longitude 31.10° East and latitude 26.334° south and has an altitude of 750 m above sea level. The site has an average mean annual rainfall of 980 mm with most rain occurring between October and April. The mean annual temperature is 18°C and hazard of drought stands at 40%. The average winter temperature is about 15 °C while for summer it is about 27°C. The soil type is the Malkerns M set soil series clay loam to sandy loam *Oxisols* mostly with acidic soil pH [16].

### 2.2 Treatments and Experimental Design

The treatments consisted of: a control with no fertiliser, [2:3:2 (22) at 300 kg $ha^{-1}$], single superphosphate (100 kg $ha^{-1}$), calcium nitrate (120 kg $ha^{-1}$) and a combination of calcium nitrate (120 kg $ha^{-1}$) and single superphosphate (100 kg $ha^{-1}$). The nutrient composition of 2:3:2 (22) is 6.3% N, 9.4% P, 6.3% K, 0.5% Zn; single superphosphate is 10.5% P; and calcium nitrate is 26.6% Ca, 13% N. A randomised complete block design (RCBD) with three replications was used. The gross size of each plot was 3 m × 2.4 m (7.2 $m^2$) consisting of five rows in inter-row spacing of 60 cm and intra-row spacing of 20 cm. The outermost one row on both sides of each plot was considered as border and not used for data collection to avoid border effects. Thus, the net plot was 3 rows × 0.6 m × 2.4 m (4.32 $m^2$).

### 2.3 Management of the Experiment

The experimental field was ploughed and disked to a fine tilth with tractor and the plots were levelled manually. According to the design, a field layout was made and each treatment was assigned randomly to the experimental units within a block. Then rows were made to the depth of 5 cm and then a local groundnut variety 'Cacajane' was planted at the rate of one seed per hill on the 3rd of December 2019. The fertilisers were applied as basal dressing at the rate specified in the treatments. Gap filling was done a week after emergence to achieve a good crop stand. Weeds were controlled manually using hand hoe. As the experiment was a rain-fed, no irrigation was applied.

### 2.4 Data Collection

#### 2.4.1 Growth parameters

The numbers of leaves were counted from three randomly selected plants in each net plot at 50% flowering, 90% flowering and maturity. The leaf area was determined at 90% flowering from three plants per net plot using a cork borer method as described by Edje and Ossom [17] and was averaged on per plant basis. Then the leaf area index was determined by dividing the leaf area ($cm^2$) per plant by the ground area occupied by each plant (60 cm × 20 cm). Plant height was measured using a measuring tape from the ground level to the apex of each of the three randomly selected plants per net plot at 50% flowering, 90% flowering and maturity. Plant canopy was measured from three randomly selected plants at 50% flowering, 90% flowering and maturity and averaged on per plant basis. A tape meter was used to measure the canopy width at the widest portion of the canopy. Numbers of branches were determined by counting the branches on the main stem from three randomly selected plants on each net plot at 50% flowering, 90% flowering and maturity and averaged to per plant basis. Aboveground plant dry biomass was determined from three groundnut plants from the net plot at 90% flowering and maturity after oven drying the plants at 65°C for 72 hours and then the weight was expressed on per plant basis.

#### 2.4.2 Yield components and yield

All yield components were recorded at harvest. Number of total pods per plant was recorded by counting the total number of pods per plant from five randomly selected plants from the net plot area. Number of mature pods per plant was recorded by counting filled and sound pods from five randomly selected plants from the net plot area. Dry pod yield was determined from the net plot after sun drying and was expressed in kilograms per hectare. Number of seeds per pod was determined by counting the number of seeds from 10 randomly selected matured pods from the five plants used for determination of the number of pods per plant. Hundred seed mass was recorded by counting hundred seeds from a bulk of shelled seed from the net plot and was weighed using a sensitive balance. The shelling percentage was determined by taking sample of about 200 g mature pods per net plot, shelling them and calculated as: $\mathrm{SP} = \frac{\mathrm{S}}{\mathrm{P}} \times 100$; where SP is shelling percentage; S is seed mass; and P is pod mass. Then the seed yield (kg $ha^{-1}$) was determined by multiplying the shelling percentage by dry pod yield.

## 2.5 Data Analysis

Data collected were analysed using GenStat 18th edition software [18]. Significantly different treatment means were compared using the Least Significant Difference (LSD) test at 5% level of significance.

## 3. RESULTS

## 3.1 Growth Parameters

### 3.1.1 Number of leaves and leaf area index

The numbers of leaves recorded at 50% and at 90% flowering were highly significantly ($p<0.01$) affected by the fertiliser treatment while the number of leaves at maturity and leaf area index at 90% flowering were not significantly affected by the fertiliser treatment. At 50% flowering and at maturity, the highest numbers of leaves per plant of 31.4 and 59.0, respectively, were recorded with the application of combination of calcium nitrate and single superphosphate followed by the application of calcium nitrate (Table 1). Similarly, calcium nitrate followed by combination of calcium nitrate and single superphosphate fertilisers gave the highest number of leaves of 48.3 and 36.1, respectively, at 90% flowering. On the other hand, the leaf area index at 90% flowering showed no significant difference among the fertiliser treatments and it ranged from 2.42 in the control to 2.94 in the combined application of calcium nitrate and single superphosphate (Table 1).

### 3.1.2 Plant height

Plant heights recorded at 50% flowering and at maturity were not significantly affected by the fertiliser treatment while it was highly significantly ($p<0.01$) affected at 90% flowering. The tallest plants of 42.17 cm and 35.17 cm at 90% flowering were recorded for treatments with calcium nitrate and a combination of calcium nitrate and single superphosphate, respectively, while the control recorded the shortest plant (28.97 cm) (Fig. 1).

### 3.1.3 Plant canopy width

Plant canopy widths recorded at 50% flowering and at maturity were not significantly affected by the fertiliser treatment while it was highly significant ($p<0.01$) affected at 90% flowering. The highest canopy widths of 41.47 cm and 40.73 cm were recorded with calcium nitrate, and combinations of calcium nitrate and single superphosphate fertiliser, respectively (Fig. 2). Similarly, these treatments gave the highest canopy width at 50% flowering and at maturity as compared to the other treatments (Fig. 2).

**Table 1. Number of leaves and leaf area index per plant of groundnut as affected by inorganic fertilizers**

| Treatment | Number of leaves at 50% flowering | Number of leaves at 90% flowering | Number of leaves at maturity | Leaf area index |
|---|---|---|---|---|
| Control | 22.0c† | 25.4d | 49.2a | 2.42a |
| 2:3:2 (22) | 25.2bc | 24.3d | 44.7a | 2.77a |
| Single superphosphate | 25.6bc | 31.7c | 47.7a | 2.47a |
| Calcium nitrate | 27.2b | 48.3a | 53.1a | 2.64a |
| Calcium nitrate and single superphosphate | 31.4a | 36.1b | 59.0a | 2.94a |
| LSD (0.05) | 3.86 | 3.02 | ns | ns |

*LSD (0.05) = Least Significant Difference at 5% level; ns= non-significant.*
*†Means in columns followed by the same letters are not significantly different at 5% level of significance*

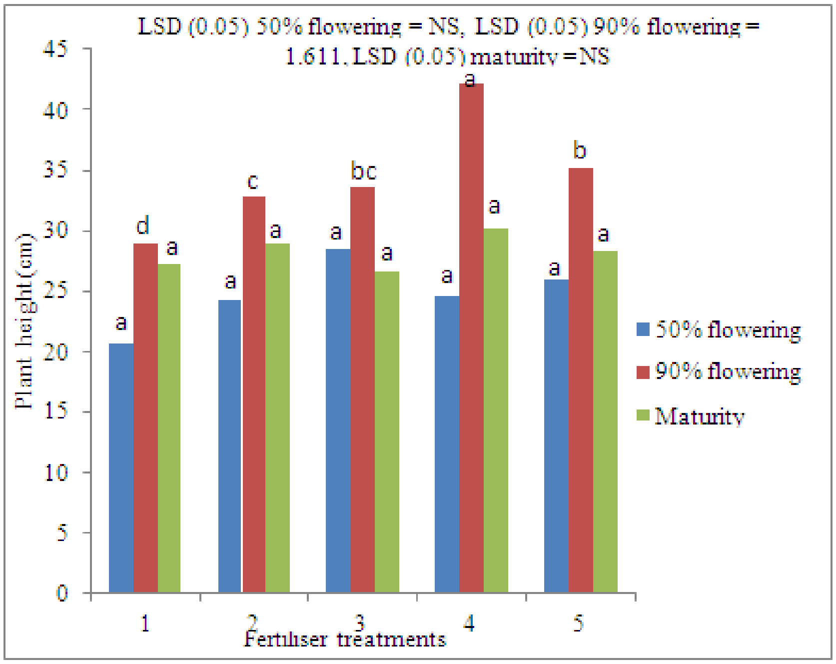


**Fig. 1. Plant height (cm) of groundnut at different growth stages as affected by inorganic fertilisers**

*Fertiliser treatments: 1) Control (no fertiliser), 2) 2:3:2 (22), 3), single superphosphate, 4) calcium nitrate, and 5) calcium nitrate and single superphosphate*

*Means in bars for same phenological stage followed by the same letters are not significantly different at 5% level of significance*

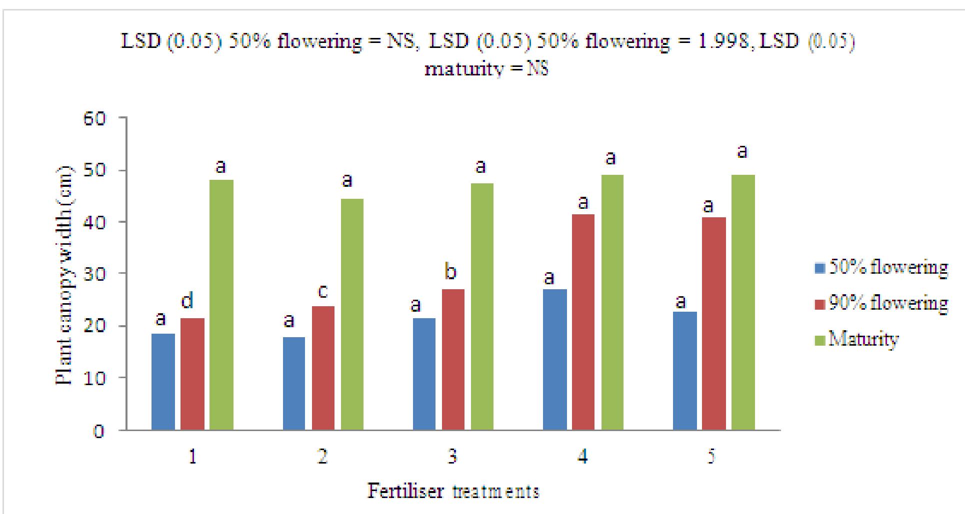


**Fig. 2. Plant canopy width (cm) of groundnut at different growth stages as affected by inorganic fertilisers**

*Fertiliser treatments: 1) Control (no fertiliser), 2) 2:3:2 (22), 3) single superphosphate, 4) calcium nitrate, and 5) calcium nitrate and single superphosphate*

*Means in bars for same phenological stage followed by the same letters are not significantly different at 5% level of significance*

#### 3.1.4 Number of branches

The numbers of branches per plant recorded at 50% flowering and at maturity were not significantly affected by the fertiliser treatments, but it was highly significantly ($p<0.01$) affected at 90% flowering. The highest number of branches per plant of 6.57 and 6.00 at 90% flowering and at maturity, respectively, were recorded for the treatment with calcium nitrate followed by the combination of calcium nitrate and single superphosphate while the control had the lowest number of branches (Fig. 3).

#### 3.1.5 Plant dry biomass

The aboveground plant dry mass at 90% flowering was significantly ($p<0.05$) affected by the fertiliser treatment while it was not significantly affected at maturity. Significantly the highest plant dry biomass per plant (20.6 g) at 90% flowering was recorded for treatment with calcium nitrate followed by the combination of calcium nitrate and single superphosphate (Fig. 4). Likewise, these treatments produced the highest plant dry biomass at maturity while the lowest plant dry mass was recorded from the control.

### 3.2 Yield components and Yield

#### 3.2.1 Number of pods and dry pod yield

The numbers of total pods and mature pods per plant were significantly ($p<0.05$) affected by the fertiliser treatments. Significantly the highest numbers of total pods per plant (28.8) and mature pods per plant (26.0) were recorded with a combination of calcium nitrate and single superphosphate fertiliser and it was statistically at par with the application of calcium nitrate alone (Table 2). In contrast, the control and 2:3:2 (22) produced significantly lowest numbers of total and mature pods per plant.

Dry pod yield was highly significantly ($p<0.01$) affected by the fertiliser treatment. Significantly the highest dry pod yield (950.6 kg $ha^{-1}$) was obtained from a combination of calcium nitrate and single superphosphate fertiliser and the yield was statistically at par with the dry pod yield (944.4 kg $ha^{-1}$) obtained from application of calcium nitrate alone (Table 2). In contrast, the lowest dry pod yield (582.8 kg $ha^{-1}$) was obtained from the control (no fertiliser application).

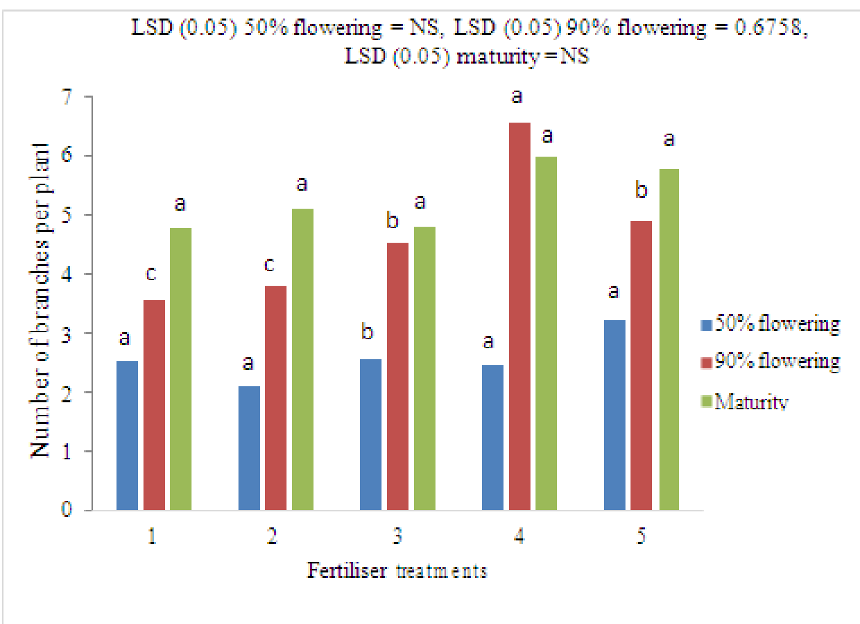


**Fig. 3. Number of branches per plant of groundnut at different growth stages as affected by inorganic fertilisers**

*Fertiliser treatments: 1) Control (no fertiliser), 2) 2:3:2 (22), 3) single superphosphate, 4) calcium nitrate, and 5) calcium nitrate and single superphosphate*

*Means in bars for same phenological stage followed by the same letters are not significantly different at 5% level of significance*

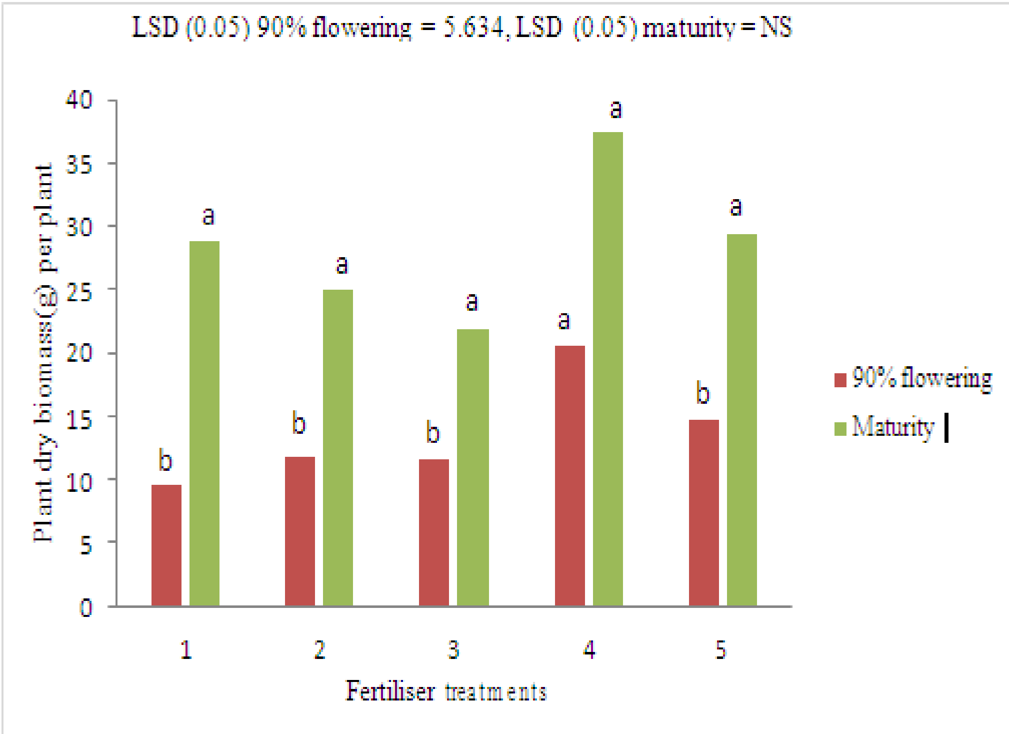


**Fig. 4. Plant dry biomass (g/plant) of groundnut at different growth stages as affected by inorganic fertilisers**

*Fertiliser treatments: 1) Control (no fertiliser), 2) 2:3:2 (22), 3) single superphosphate, 4) calcium nitrate, and 5) calcium nitrate and single superphosphate.*

*Means in bars for same phenological stage followed by the same letters are not significantly different at 5% level of significance.*

**Table 2. Number of total pods per plant, number of mature pods per plant and dry pod yield of groundnut as affected by inorganic fertilisers**

| Treatment | Number of total pods/plant | Number of mature pods/plant | Dry pod yield (kg ha$^{-1}$) |
|---|---|---|---|
| Control | 20.9b† | 18.5b | 582.8c |
| 2:3:2 (22) | 19.0b | 18.3b | 736.1b |
| Single superphosphate | 24.1ab | 22.9ab | 737.9b |
| Calcium nitrate | 27.5a | 24.8a | 944.4a |
| Calcium nitrate and single superphosphate | 28.8a | 26.9a | 950.6a |
| LSD (0.05) | 5.43 | 5.17 | 123.9 |

*LSD (0.05) = Least Significant Difference at 5% level; ns = non-significant.*

*†Means in columns followed by the same letters are not significantly different at 5% level of significance*

### 3.2.2 Number of seeds/pod, hundred seed mass, shelling percent and seed yield

The number of seeds per pod was not significantly affected by the fertiliser treatment while hundred seed mass, shelling percentage and seed yield were highly significantly ($p < 0.01$) affected by the fertiliser treatment. The highest hundred seed mass (82.8 g), shelling percentage (70.6) and seed yield (671.6 kg ha$^{-1}$) were recorded from a combination of calcium nitrate and single superphosphate fertilisers and followed by sole application of calcium nitrate fertiliser (Table 3). In contrast, the lowest hundred seed mass (45.7 g), shelling percentage (62.3) and seed yield (354.0 kg ha$^{-1}$) were obtained from the control (no fertiliser application) (Table 3).

**Table 3. Number of seeds per pod, hundred seed mass, shelling percentage and seed yield of groundnut as affected by inorganic fertilisers**

| Treatment | | Hundred | | |
|---|---|---|---|---|
| | Number of seeds/pod | Seed mass (g) | Shelling percentage | Seed yield (kg $ha^{-1}$) |
| Control | 1.7a† | 45.7b | 62.3c | 354.0c |
| 2:3:2 (22) | 1.8a | 57.6b | 65.1bc | 478.6b |
| Single superphosphate | 2.0a | 57.3b | 63.3bc | 471.2b |
| Calcium nitrate | 1.8a | 76.6a | 66.3b | 626.0a |
| Calcium nitrate and single superphosphate | 1.9a | 82.8a | 70.6a | 671.6a |
| LSD (0.05) | Ns | 14.26 | 3.84 | 96.4 |

*LSD (0.05) = Least Significant Difference at 5% level; ns= non-significant.*
*†Means in columns followed by the same letters are not significantly different at 5% level of significance*

## 4. DISCUSSION

### 4.1 Growth Parameters

#### 4.1.1 Number of leaves and leaf area index

Application of calcium nitrate and combination of calcium nitrate and single superphosphate fertilisers significantly increased the numbers of leaves per plant of groundnut (Table 1). The increased numbers of leaves with the application of these fertilisers might be due to improved nodulation and better root and shoot growth due to the synergistic effect of calcium, phosphorus and nitrogen present in the fertilisers. In agreement with this result, Kabir et al. [19] reported that the application of phosphorus, calcium and boron fertilisers improved the growth of groundnut. Similarly, Mouri et al. [20] reported that application of 60 kg P $ha^{-1}$ gave the highest leaf area index (2.02) of groundnut. Jadhav and Narkhede [21] also reported increased leaf area in groundnut with increasing levels of P fertilizer up to 60 kg P $ha^{-1}$.

#### 4.1.2 Plant height

The application of calcium nitrate and a combination of calcium and single superphosphate significantly increased plant height (Fig. 1). This might be due to the adsorption of calcium ion on the soil exchange complex which then increased the availability of nutrients and hence promoted growth. Moreover, the phosphorus fertiliser might have enhanced root development which improved the supply of other nutrients and water to the growing parts of the plants. In line with this result, Rahman [22] observed that calcium significantly influenced plant height and recorded the tallest plants with the application of 150 kg Ca $ha^{-1}$ whilst the shortest plants were from the control plots. Likewise, Gobarah et al. [23] reported that increasing rate of phosphorus significantly increased vegetative growth of groundnut. Kamara et al. [24] also obtained significant increase in plant height of groundnut with the application 40 kg P $ha^{-1}$ as compared to the control.

#### 4.1.3 Plant canopy width

Plant canopy width was significantly increased with calcium nitrate and a combination of calcium nitrate and single superphosphate application (Fig. 2). Phosphorus plays an important role in cell division and development of new tissue; which in turn increases canopy width of the plants. Calcium might have also maintained chemical balance in the soil and reduced soil acidity which has a positive influence on the canopy width. Moreover, the application of phosphorus fertiliser enhanced root development which might have improved the supply of other nutrients and water to the growing parts of the plants, resulting in an increased photosynthetic area and hence more canopy width [25].

#### 4.1.4 Number of branches

Calcium nitrate and a combination of calcium nitrate and single superphosphate application significantly increased the number of branches per plant (Fig. 3). Calcium helps maintain chemical balance in the soil and neutralizes acid soils thereby creating favourable conditions for the plant growth. In addition, phosphorus also promotes root growth, enhances nutrient and water use efficiency and might increase the number of branches per plant. In conformity with this result, Rahman [22] noted that calcium fertilization influenced the number of branches per plant significantly with the highest number of branches produced with the application of 150 kg

Ca $ha^{-1}$. Similarly, Kamara et al. [11] obtained the highest number of branches per plant (9.5) with the application of 200 kg Ca $ha^{-1}$. Moreover, Mouri et al. [20] recorded the highest number of primary branches per plant (10.70) with the application of 60 kg P $ha^{-1}$.

#### 4.1.5 Plant dry biomass

The aboveground plant dry biomass was significantly increased with the application of calcium nitrate and a combination of calcium nitrate and single superphosphate (Fig. 4). The increased aboveground dry biomass might be due to maximum leaf number, leaf area index, plant height, canopy width and branching recorded in response to the above fertilizers. In agreement with this result, Kabir et al. [19] reported the highest dry biomass per plant of groundnut with the application of 165 kg Ca $ha^{-1}$ and 50 kg P $ha^{-1}$. Similarly, El- Habbasha et al. [25] obtained the highest dry matter (50.45 g $plant^{-1}$) of groundnut with the application of 60 kg P $ha^{-1}$.

### 4.2 Yield Components and Yield

#### 4.2.1 Number of pods per plant and number of seeds per pod

The application a combination of calcium nitrate and single superphosphate significantly increased the numbers of total pods and mature pods per plant (Table 2). The supply of calcium in the soil might have played an important role in pod formation as developing pegs and pods can directly absorb soil calcium similar to absorption by roots [11]. Adequate supply of calcium reduces the percentage of aborted seeds (empty pods or “pops”) and gives more filled pods [11]. The higher production of pods with the application of phosphorus might be due to an important role of P in legumes in enhancing nodule formation and fixation of atmospheric nitrogen [26]. In agreement with this result, El-Habbasha et al. [25] reported that increasing phosphorus levels increased the number of pods per plant. Likewise, Kabir et al. [19] obtained the highest number of pods per plant of 18.96 and 18.47 with the application of 50 kg P $ha^{-1}$ and 110 kg Ca $ha^{-1}$, respectively. Kamara et al. [11] also obtained significantly highest number of filled pods per plant (23.1) with the application of 100 kg Ca $ha^{-1}$ as compared to the control. Ranjit [27] also reported significant increases in total number of pods per plant from 16.89 to 22.78 as the rate of P increased from 37.5 to 75 kg P2O5 $ha^{-1}$.

In contrast, the fertiliser treatments did not have significant effect on the number of seeds/pod (Table 3). This might be due to local variety used for the experiment which is uniformly adapted to produce two seeds per pod as the number of seeds per pod is more of a varietal trait and less affected by crop management practices.

#### 4.2.2 Shelling percentage and hundred seed mass

Combination of calcium nitrate and single superphosphate fertilisers produced significantly highest shelling percentage and 100 seed mass (Table 3). The soil used in the current study was acidic. Thus, the application of Ca and P fertilizers might have increased nutrients availability to the crop during the growing season which leads to higher partitioning of assimilates to the pods and ultimately increased number of filled pods and shelling percentage. Moreover, P is an important nutrient for legumes in particular as it is a key constituent of ATP and plays significant role in energy transformation in plant and also roles in seed formation [26]. In line with this result, Rahman [22] observed positive effect of calcium application on 100 seed weight and shelling percentage of groundnut. Likewise, Velasquez and Ramirez [28] reported a positive effect of calcium on pods and it increased weight of seeds of groundnut. Kabir et al. [19] also obtained the highest 100 pod weight and shelling percentage with the application of 50 kg P $ha^{-1}$ and 165 kg Ca $ha^{-1}$.

#### 4.2.3 Dry pod and seed yields

Combined application of calcium nitrate with single superphosphate fertilisers resulted in the highest dry pod and seed yields (Table 2 and Table 3). The high yields obtained from the treatments containing calcium could have been due to increased cation exchange and reduced soil acidity which caused positive effects on the growth and productivity of the groundnut [29]. Calcium and phosphorus increase the number of filled pods and hence the seed and pod yields [11]. In line with this result, Kamara et al. [8] reported that pod yield increased by 49.3% at 20 kg and by 57.8% at 40 kg P $ha^{-1}$ compared with unfertilized plots. Similarly, Kamara et al. [30] also reported the highest seed yield of groundnut with application of 100 kg Ca $ha^{-1}$ and 40 kg

P2O5 $ha^{-1}$ whilst the control had the lowest seed yield.

## 5. CONCLUSION

The highest number of pods per plant, dry pod yield (kg $ha^{-1}$), seed yield (kg $ha^{-1}$), hundred seed mass (g) and shelling percentage were obtained with the application of combination of calcium nitrate and single superphosphate fertilisers. Thus, combined application of calcium nitrate (120 kg $ha^{-1}$) and single superphosphate (100 kg $ha^{-1}$) can be used to increase the productivity of groundnut in the study area. However, to reach at a conclusive recommendation, the experiment has to be repeated over more years with inclusion of more treatments and economic evaluation.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Gregory WC, Krapovickas A, Gregory MP. Structure, variation, evolution, and classification in *Arachis*. In: Advances in Legume sciences. Royal Botanical Gardens, Kew Gardens, London, United Kingdom; 1980.
2. Weiss EA. Oilseed crops. Blackwell Science. London, Britain; 2000.
3. FAO (Food and Agriculture Organization). Crop Production Statistics. Food and Agriculture Organization of the United Nations, Rome, Italy.
   Available:http://www.fao.org/faostat/en/#data.
   Accessed on 20/02/2021; 2018.
4. Savage GP, Keenan JI. The composition and nutritive value of groundnut kernels. In: Samrtt, J. (ed.). A Scientific Basis for Improvement. Chapman and Hall, St Edmundsbury Press, Great Britain. 1994; 173–205.
5. Taru VB, Kyagya IZ, Mshelia SI, Adebayo EF. Economic efficiency of resource use in groundnut production in Adamawa State of Nigeria. World Journal of Agricultural Sciences. 2008;4(5):896-900.
6. Ghosh PK, Bandyopadhyay KK, Wanjari RH, Manna MC, Misra AK, Mahonty M, Subba RA. Legume effect for enhancing productivity and nutrient use efficiency in major cropping systems-An Indian perspective: A review. Journal of Sustainable Agriculture. 2007;30(1):59-86.
7. Zharare GE, Blamey FP, Asher CJ. Initiation and morphogenesis of Groundnut (*Arachis hypogaea* L.) pods in Solution Culture. Annals of Botany. 1998;81:391-396.
8. Kamara AY, Ekeleme F, Kwari JD, Omoigui LO, Chikoye D. Phosphorus effects on growth and yield of groundnut varieties in the tropical savannas of northeast Nigeria. Journal of Tropical Agriculture. 2011a;49(1-2):25-30.
9. Ntare BR, Diallo AT, Ndjeunga AT, Waliyar F. Groundnut Seed Production Manual. International Crops Research institute for the Semi-Arid Tropics (ICRISAT). Andhra Pradesh, India; 2008.
10. Singh F, Oswalt DL. Groundnut Production Practices. Skill Development series No. 3. ICRSAT Training and Fellowship Program International Crops Institute for the Semi-Arid Tropics, Patancheru, Andra Pradesh 502 324, India; 1995.
11. Kamara EG, Olympio NS, Asibuo JY. Effect of calcium and phosphorus fertilizer on the growth and yield of groundnut (*Arachis hypogaea* L.). International Research Journal of Agricultural Science and Soil Science. 2011b;1(8):326-331.
12. Poehlman JM. The Mungbean. Oxford and IBH Publishing Co.Pvt. New Delhi, India; 1991.
13. Gascho GJ, Davis JG. Mineral nutrition of groundnut. The groundnut crops: A scientific basis for improvement. Chapman and Hall, London, United Kingdom; 1994.
14. Abdulkadir M, Kevin M, Patrick AN. Effects of rhizobium inoculation and supplementation with P and K on growth, leaf chlorophyll content and nitrogen fixation of bush bean varieties. American Journal of Research Communication. 2014;2(10):49-87.
15. Intodia SK, Mahnot SC, Sahu MP. Effect of organic manures and phosphorus on growth and yield of groundnut (*Arachis hypogaea* L.). Crop Research. 1998;5(1): 22-26.
16. Murdoch G. Soils and land capability in Swaziland. Swaziland Ministry of Agriculture, Mbabane, Swaziland; 2000.
17. Edje OT, Ossom EM. Crop Science Handbook, 2nd edition. Blue Moon Publishers, Manzini, Swaziland; 2009.

18. GenStat. GenStat Procedure Library Release.18th edition. VSN International Ltd; 2015.
19. Kabir R, Yeasmin S, Mominul Islam AKM, Sarkar MA. Effect of phosphorus, calcium and boron on the growth and yield of groundnut (*Arachis hypogaea* L.). International Journal of Bio-Science and Bio-Technology. 2013;5(3):51-57.
20. Mouri SJ, Sarkar MAR, Uddin MR, Sarker UK, Kaysar MS, Hoque MMI. Effect of variety and phosphorus on the yield components and yield of groundnut. Progressive Agriculture. 2018;29(2):117-126.
21. Jadhav AS, Narkhede RN. Pattern of dry matter accumulation of groundnut as influenced by nitrogen and phosphorus fertilization. Madras Agric. J. 1983;69:756-766.
22. Rahman MA. Effect of Calcium and *Bradyrhizobium* inoculation of the growth, yield and quality of groundnut (*Arachis hypogaea* L.). Bangladesh Journal Scientific Industrial Research. 2006;41(3-4):181-188.
23. Gobarah ME, Mohamed MH, Tawfik MM. Effect of phosphorus fertilizer and foliar spraying with zinc on growth, yield and quality of groundnut under reclaimed sandy soils. Journal of Applied Science Research. 2006;2(80):491-496.
24. Prihar SS, Tripathi RS. Dry matter, nodulation and nutrient uptake in chickpea as influenced by irrigation and phosphorus. Experimental Agriculture. 1989;25:349-355.
25. El-Habbasha SF, Kandil AA, Abu-Hagaza NS, El-Haleem AA, Khalafallah MA, Behairy TG. Effect of phosphorus levels and some biofertilizers on dry matter, yield and yield attributes of groundnut. Bulletin of Faculty of Agriculture, Cairo University. 2005;56(2):237-252.
26. Brady NC, Weil RR. The nature and properties of soils, 13th Ed. Pearson Education (Singapore) Pvt. Ltd; 2002.
27. Ranjit R. Response of Groundnut genotypes to lime and phosphorus levels in Coastal Alluvial Soil of North Karnataka. M.Sc Thesis submitted to the Department of Soil Science and Agricultural Chemistry College of Agriculture, University of Agricultural Sciences, India; 2005.
28. Velasquez MJR, Ramirez R. Effect of Ca localization on the soil on development and formation of groundnut fruit (*Arachis hypogaea* L.). Agronomia- Tropical. 1985; 35(4-6):29-39.
29. Murata MR, Zharare GE, Hammers PS. pH of the production zone affects reproductive growth of groundnut. Journal of Plant Nutrition. 2003;31(1):69-79.
30. Kamara EG, Olympio NS, Asibuo JY, Kabbia MK, Yila KM, Conteh AC. Effect of Calcium and Phosphorus Fertilizer on Seed Yield and Nutritional Quality of Groundnut (*Arachis hypogaea* L.). International Journal of Agriculture and Forestry. 2017;7(6):129-133.


---



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*http://www.sdiarticle4.com/review-history/67600*