Response of Groundnut (*Arachis hypogea*) to Inorganic Fertiliser Use in Smallholder Farming of Makonde District, Zimbabwe

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Abstract
A study was carried out in Makonde district to evaluate the effect of using compound D and gypsum as basal dressings on growth, quality and yield of groundnuts (*Arachis hypogea*). A Randomised Complete Block design (RBCD) with three replicates per treatment was used in carrying out the study, where gypsum treated plots, compound D treated plots as well as unfertilised treatment. The treatments had gypsum and compound D applied as basal fertilizers at a rate of 300kg ha^{-1} each whilst the traditional way (control) received no fertilizers. The data was analysed using a non-parametric test, the Mann-Whitney U test at P<0.05, comparing samples using mean ranks and the sum of ranks. Compound D fertilized crop an average yield of 630kg ha^{-1} as compared to gypsum fertilized plots and the traditional method yielded 550 and 510kg ha^{-1} respectively. The results of the study showed that both compound D and gypsum resulted in higher groundnut yield compared to unfertilised treatment though compound D out yielded gypsum treatment. Smallholder farmers are therefore recommended to grow groundnuts using basal fertilizers to maximise yields in the form of Compound D or gypsum.
Keywords: *Arachis Hypogea*, basal fertilisers, traditional method

1. Introduction

Groundnuts (*Arachis hypogea*), is one of the most important oil seeds traditionally grown by smallholder farmers in Zimbabwe. The crop has been grown for a number of years and has been an important component of the Africans' diet. Groundnuts are an important food crop and a source of both fat and protein and mostly locally utilized for nutrition (25% - 32% proteins and 42% - 52% oil) (Nyakanda and Hilderbrand, 1999; Ibrahim and Eleiwa, 2008; Okello *et al*, 2010) as well as its importance as a raw material for industrial produce such as animal feed and confectionery (Nhongonhema, 1998; Rob, 2011). Groundnuts do well on deep, well drained sandy, sandy loam or loamy sand soils with a pH ranging between 5.3- 6.5 (Farmer management Handbook, 2010). Groundnut does well in a well-prepared seedbed, being sown, soon after the first effective rains to help maximise yields and minimise pest severity (Nyakanda and Hildebrand, 1999).

In Zimbabwe, about 170 00 hectares of groundnuts are currently grown by smallholder farmers mainly for home consumption to supplement the staple food maize (ZFC Fact Sheet, 2004). Yields are usually less than half a tonne in smallholder farmers as compared to commercial farmers who get yields of up to 4t ha^{-1}(Farmers Handbook, 1994). The low productivity has been attributed to declining soil organic matter in the soils and inappropriate fertiliser application practices (Compaore, 2011).

Gypsum has been used on other crops such as potatoes. Results have shown that it improves crop quality and helps prevent some diseases such as common scab in potatoes (Summer, 1998). Good fruit quality is enhanced by the provision of calcium, which is an important mineral in groundnut production. A split application of gypsum, firstly during the onset of flowers and secondly at 10 weeks was believed to be more effective in the quality of groundnuts (Nyakanda and Hilderbrand, 1999).

Compound fertilizers are formulated to supply different proportions of Nitrogen, Phosphorus, and Potassium for specific plant species and they are an essential part of crop establishment. Compound D ($N_7P_{14}K_7$) plays a very important role in achieving high yields in crops such as maize, rice, barley, sugar beans and other small grains like sorghum, rapoko and finger millet (Z.F.C fact sheet, 2009). It ensures that the crop obtains good nutrition right from germination as it is applied at planting. The constituent elements of compound D fertilizer are all major elements that are required for plant growth though they play different roles (Farmer management handbook, 1994).

1.2 Statement of the problem

Smallholder farmers in Makonde district have been growing groundnuts for many years but realizing low yields of about 400-500kg ha^{-1} (Nyakanda and Hilderbrand, 1999). Growing the crop without any soil amendment could be a major cause for the low yields. Gypsum and compound D are also believed to offer an increase in yield and quality of groundnuts (Litsinger, 2004), thus the purpose of the research evaluate the use gypsum and compound D on the productivity of groundnut (*Arachis hypogea*).

2.0 Materials and Methods

The study was carried Makonde District, in Mashonaland West Province. The district falls in agro-ecological region 2b. The region is characterised by intensive farming based on crop production though intensive beef and dairy production are also common. It receives rainfall amounts of about 700-1050 mm annually and has 16-18 wet pentads per season (Nyakanda and Hilderbrand, 1999). The region experiences temperature ranges of between, 20-30°C, in summer and between 4-19°C, in winter. It is characterised by savanna type of woodland and has an altitude of 1200m above sea level. The area has light sands to loam sand soils. Potatoes, maize, soya beans, groundnuts and tobacco are the common crops grown in the region. The area was found suitable for the research as most farmers in groundnuts production are realising low yields (Surveyor General, 1999).

2.1Treatment description and experimental design

A Randomised Complete Block Design (RCBD) was used in carrying out the experiment. Randomisation involves the assignment of treatments to units (plots) following some random process to eliminate bias (Canhao, 2004). Each of the three blocks contained nine equal plots measuring 10m x 10m and each of the two treatments and the unfertilised treatment were replicated three times. A cleared metre was left between each of the plots to eliminate border effects.

Nine plots in the three blocks were treated with gypsum at a rate of 150kg ha^{-1}, while the other nine were treated with compound D fertilizer at the rate of 150kg ha^{-1}. Nothing was added to the other nine plots which is the traditional and common way of growing groundnuts. Groundnuts were planted in each of the twenty seven plots at the rate of 100 kg ha^{-1}.

2.3 Field operations

The land was ploughed after the first effective rains at a depth of 25cm using an ox drawn plough for all the treatments. An ox drawn triangular harrow was then used to prepare a fine tilth. The land was levelled and lines at a depth of 6cm in each plot were marked as shallow planting will result in patch germination (Nyakanda and Hilderbrand, 1999). Compound D and gypsum was applied. A little soil was put on top of the fertilisers to prevent direct contact with the ground nut seed at planting. No fertilizer was added into the other nine experimental plots. Seeds were then hand planted one seed per station on the same day for all the plots at 10cm in row spacing and inter row spacing 45cm for all the treatments. A short season variety, Valencia R2 was used. Weeding was done manually whenever they had emerged.

2.4 Measurements

The measurements assessed the yield and yield components from a net plot area of 25m². Number of days taken to germinate, days to flowering , leaf size was recorded four weeks after crop emergence, 1000 nut weight and number of filled pods were measured. Above ground biomass, was also measured at physiological maturity.

2.5 Data analysis

A non-parametric test, Mann-Whitney U was implemented. The Mann-Whitney U test compares samples using mean ranks and sum of ranks. $P>0.05$ implies no significant difference between the samples, whilst $P<0.05$ implies a significant difference between the samples being compared.

3. Results

3.1Days to emergence

There was no significant difference (P=1.00) on the number of days taken to germination and emergence between compound D, gypsum and untreated groundnuts (Appendix 1). The number of days taken by groundnut seed to germinate and emerge for all the treatments was six (Table 1).

3.2 Germination Rate

There was a significant difference (P=0.025) on the rate of germination between compound D and gypsum treated plots (Appendix 2). Compound D plots achieved a 97% germination rate which differs significantly with 95% germination rate achieved by gypsum treatment as well as unfertilised treatment. However there was no difference between gypsum treated and unfertilised treatment (Table 1).

3.3 Number of days to flowering

There was a significant different (P=0.034) in terms of the number of days to flowering (Appendix 5). Compound D treated plants flowered early (50 days) than gypsum (57 days) and unfertilised treatment (61 days) (Table 1). There was also a significant difference between gypsum and unfertilised treatment (Appendix 7).

3.4 Leaf size at 4 weeks after crop emergence

There was a significant difference (P=0.046) in leaf size between compound D and gypsum treated plots (Appendix 8). There was also significant difference between compound D treated and the unfertilised treatment at ($P<0.05$). Leaf size between compound D and unfertilised treatment differed significantly at $P<0.05$ (Appendix 9).The lowest (3.9cm) leaf size, then gypsum treatment (4.4cm) and Compound D treatment (5.4cm) had the highest leaf size (Table 1).

3.5 Plant biomass at physiological maturity

There was a significant difference (P=0.050) between the plant biomass obtained from compound D, gypsum and the untreated (control) plants (Appendix 11). Highest plant biomass was 99g for compound D then 92g for gypsum treatment while the least biomass (88g) was obtained for untreated plots (Table 1).

3.6 Number of filled pods at physiological maturity

There was a significant difference (P=0.043) in the number of filled pods at physiological maturity for compound D and gypsum treated plots as well as the untreated plots (Appendix 12). The lowest number of filled pods was observed in a treatment without fertiliser which had an average of 18 pods per plant. Gypsum treated plants had 23 pods while the highest was obtained in Compound D treated plant which had 29 pods.

3.7 One hundred shelled nut weight

The results of the study showed that there was a significant difference (P=0.050) in the weight of 100 shelled groundnut for compound D, gypsum and unfertilised treatment (Appendix 13). Compound D treated had 63g while gypsum had 55g and unfertilised treatment had 51g (Table1).

3.8 Plant dry matter

The results obtained from the study showed a significant difference (P=0.050) in plant dry matter for compound D, gypsum and unfertilised plots. Compound D treatment had 698 kg ha^{-1}, while gypsum had 498 kg ha^{-1} while the lowest dry matter was observed in unfertilised plots (297 kg ha^{-1}) which were significantly different from the other treatments (Table 1).

Table 1: Number of days to emergence, germination rate, number of days to flowering, leaf size, plant biomass, number of filled pods, 100, net weight and plant dry matter as affected by soil amendment

Treatment	**DE**	**GR%**	**DF**	**LS**	**PB**	**NP**	**NW**	**PDM**
Compound D	6a	97b	50a	5.4c	99c	29c	63c	698c
Gypsum	6a	95a	57b	4.4b	92b	23b	55b	498b
No Fertiliser	6a	95a	61c	3.9a	88a	18a	51a	297a
Significance	NS	*	*	*	*	*	*	*

*Significance at ά=0.05, NS-Not Significant

DE (number of days to emergence), GR% (Percentage germination rate), DF (number of days to flowering), LS (leaf size at 4 weeks), PB (above ground plant biomass), NP (number of filled pods), NW (100 Nut weight), PDM (plant dry matter).

4. Discussion

4.1 Number of days to germination

There was no significant difference in the number of days taken to germination and emergence across all the treatments. This was because fertilization does not affect germination but it only enhances growth through initiating root development and providing nutrients needed for growth (Tillman, Jowers and Katsvairo, 2009). Basal fertilizer intake is not done by the seed, but by the roots, thus the equal number in germination days.

4.2 Germination rate

The highest germination was achieved in Compound D plots compared to gypsum and unfertilised treatments because seedlings from compound D plots managed to receive nutrients early in their growth enhancing root development and growth hence they vigorously grow as compared to the other treatments. Moreover gypsum is more of a soil amender rather than a fertilizer (Litsinger, 2004).

4.3 Number of days to flowering

Compound D plots managed to get quantities of potassium, phosphorus and nitrogen as well as calcium (65%), which are basic nutrients in peanut production at the initial stage of growth. This enhanced vigorous and quick growth of plants in such plots leading to early flower initiation (Tillman, Jowers and Katsvairo, 2009). Moreover, gypsum contains calcium and sulphur which are mostly needed for pod and seed development (Tillman, Jowers and Katsvairo, 2002). Since gypsum decreases the pH of sodic soils to ranges acceptable for growth of most crop plants, making some nutrients like nitrogen, magnesium and potassium available may have led to quickening of growth processes (Ibrahim and Eleiwa, 2008; Brown, 2011) including flowering gypsum plots flowering earlier than untreated plots (Epstein, 1961).

4.4 Leaf size 4 weeks after crop emergence

Compound D treated plants had higher leaf size because of quick growth of groundnuts since nutrients were readily available. The gypsum which was incorporated into the soil led to the availability of some crop nutrients in the gypsum treated plants resulting in bigger leaf size (Epstein, 1961). No fertiliser treatments could have lacked some of the nutrients such as phosphorus and potassium that were required for growth.

4.5 Plant biomass at physiological maturity

Compound D plots p than the other two treatments, gypsum and control. This could have been caused by the compound D fertilizer applied to the treatment which led to the hastening of the various growth processes such as days to flowering and formation of pods. This relates to the work of (Ibrahim and Eleiwa, 2008) who found that all the yield parameters of groundnuts had the same trend in all the yield aspects that were measured such as leaf size, pod size, 100 grain yield that subsequently resulted in an increase in above ground biomass.

4.6 Number of filled pods at physiological maturity
Compound D plots produced the highest number of filled pods as compared to gypsum and the untreated plots. This was because of the fact that compound D plots containing mineral NPK started flowering early hence started pegging early in the season as compared to other plots leading to early attainment of pod maturity (Mugedi *et al*, 2010). Gypsum plots would have done well if gypsum was applied as a top dresser at pegging (Nyakanda and Hilderbrand, 1999) or at the onset of flowering. This would have been caused by the addition of calcium in gypsum which is needed by peanuts for pod filling (Tillman *et al*, 2009).
4.6 One hundred shelled groundnut weight
Compound D treated plots had the highest weight of 100 shelled groundnuts compared to gypsum fertilized plots as well as the control. This was attributed by compound D fertilizer which was applied as basal dressing resulting in vigorous and healthy growth of groundnuts leading to the extensive grain filling leading to heavy nuts (Otiena *et al,* 2007). The application of gypsum also led to some soil amendments, resulting in the provision of certain important nutrients such as Calcium and Sulphur which led to heavy nuts being produced in gypsum plots compared to the untreated plots. Light nuts were produced in the control plots since no nutrients were added to the treatment. Gypsum can also be used as a source of sulfur. Soils that may be responsive to sulfur may respond to the sulfur contained in gypsum (Brown, 2011).
4.7 Plant fresh and dry weight
Compound D plots had the highest plot fresh and dry weight. This was as a result of a high weight in 100 shelled groundnuts which was attributed by the application of compound D at the initial stages of growth. This is in line with the work that was carried out by (Otiena *et al*, 2007) who realised high dry matter and total dry matter in grain legumes. In another study of sorghum-groundnut rotation, the application of organic fertilisers resulted in an increase in the plant biomass (Compaore *et al*, 2011).

5. Conclusion and Recommendations
The research study has shown that compound D fertilizer plots had a higher growth rate and managed to flower earlier, resulted in more pods, bigger nuts as well as higher biomass compared to gypsum and control plots. The study also revealed that applying compound D as a basal fertilizer has a role in increasing groundnut yield as compared to using gypsum as basal fertilizer. Compound D fertilization enhanced quick growth, ensuring a good plant stand which bore healthy flowers and healthy pods producing heavy nuts. This in turn contributed positively to the biological yield.

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APPENDICES

Results for **(1)** days to germination and emergence between compound D, gypsum and untreated plots, **(2)** comparison between Compound D and gypsum, **(3)** comparison between compound D and unfertilised, **(4)** comparison between gypsum and unfertilised treatments

	(1) Germination and Emergence	**(2)** Germination Rate	**(3)** Germination Rate	**(4)** Germination Rate
Mann-Whitney U	4.500	.000	.000	.000
Wilcoxon W	10.500	6.000	6.000	6.000
Z	.000	-2.236	-2.236	-2.236
Asymptotic Significance (2-tailed)	1.000	.025	.025	.025
.Exact Sig. [2*(1-tailed Sig.)]	1.000(a)	.100(a)	.100(a)	.100(a)

Number of days to flowering: (5) comparison between Compound D and gypsum, **(6)** comparison between compound D and unfertilised, **(7)** comparison between gypsum and unfertilised treatments.

	(5) N Days	**(6)** N Days	**(7)** N Days
Mann-Whitney U	.000	.000	.000
Wilcoxon W	6.000	6.000	6.000
Z	-2.121	-2.023	-2.121
Asymptotic Significance. (2-tailed)	.034	.043	.034
Exact Sig. [2*(1-tailed Sig.)]	.100(a)	.100(a)	.100(a)

Leaf size at 4 weeks after crop emergence: (8) comparison between Compound D and gypsum, **(9)** comparison between compound D and unfertilised, **(10)** comparison between gypsum and unfertilised treatments.

	(8) leaf size (cm)	**(9)** leaf size (cm)	**(10)** leaf size (cm)
Mann-Whitney U	.000	.000	.000
Wilcoxon W	6.000	6.000	6.000
Z	-1.993	-1.993	-1.964
Asymptotic Significance. (2-tailed)	.046	.046	.050
Exact Sig. [2*(1-tailed Sig.)]	.100(a)	.100(a)	.100(a)

Appendix **(11)** shows plant biomass at physiological maturity between gypsum compound D and no fertiliser , **(12)** number of filled pods between compound D, gypsum and the untreated plots, **(13)** 100 shelled nut weight between Compound D, gypsum and unfertilised, **(14)** Plant dry mass between compound D, gypsum and untreated.

	(11) Plant biomass (g)	**(12)** N of Filled pods	**(13)** G Nut Weight (g)	**(14)** G Nut Weight (g)
Mann-Whitney U	.000	.000	.000	.000
Wilcoxon W	6.000	6.000	6.000	6.000
Z	-1.964	-2.023	-1.964	-1.964
Asymptotic Significance. (2-tailed)	.050	.043	.050	.050
Exact Sig. [2*(1-tailed Sig.)]	.100(a)	.100(a)	.100(a)	.100(a)