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Bangladesh J. Sci. Ind. Res. **51(4)**, 285-290, 2016

BANGLADESH JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

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Yield and yield components of *Arachis hypogaea* L. as influenced by NPK chemical fertilizers, farm yard manure and gypsum

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Abstract

Field trials were conducted to evaluate the effect of chemical fertilizers, farmyard manure (FYM) and gypsum on yield and yield components of groundnut (*Arachis hypogea* L.). There were nine treatments included unfertilized treatment and full doses of recommended NPK fertilizers (65:100:75 kg/ha) or reduced doses of recommended NPK fertilizers (30:50:37.5 kg/ha) and FYM@10 t/ha in combination with different levels (0, 150, 300 and 450 kg/ha) of gypsum. The results exhibited that full dose of NPK fertilizers with 300 kg/ha gypsum treatment gave significantly ($P<0.05$) higher seed yield (2777.28 kg/ha) than the full dose of NPK fertilizers alone (typical control) which had 2276.05 kg/ha. On the other hand, application of reduced dose of NPK fertilizers + 10 t/ha FYM with 450 kg/ha gypsum resulted 2609.88 kg/ha seed yield followed by 300 kg/ha gypsum application which had 2521.98 kg/ha and both values were statistically similar. Thus, use of 300 kg/ha gypsum could give high seed yield of groundnut with full dose of NPK fertilizers alone or reduced dose of NPK fertilizers and 10 t/ha FYM. However, combined application of organic and inorganic fertilizers is better practice especially on sandy regosol when considering human and soil health.

Keywords: Groundnut, Gypsum; Farm yard manure; NPK chemical fertilizers; Seed yield

Introduction

Groundnut (*Arachis hypogaea* L.) is one of the valuable vegetable oil crops and its seeds contain high amount of edible oil (47%) and protein (38%) (Atasie *et al*., 2009). As a result, it is used for human consumption. Groundnut cake and haulms are also used as animal feed and organic manure (Ahmad and Rahim, 2007; Shah *et al.*, 2012). In Sri Lanka, the cultivated extent and production of groundnut were 11609 ha and 21953 mt respectively in 2012 according to the Department of Agriculture, Sri Lanka. It is grown mainly in dry and intermediate zones of Sri Lanka. Groundnut being leguminous crop has the ability to fix atmospheric nitrogen with the help of *Rhizobium* bacteria being living within the root nodules of legume crop and generally it contributes about 25 kg/ha nitrogen (Veeramani and Subrahmaniyan, 2011). In usual agriculture, most of the farmers apply inadequate and imbalanced mineral nutrients which may cause for low groundnut productivity (Compaore *et al*., 2011) especially on sandy soil. Therefore, proper nutrient management is a crucial way to obtain optimal yield with good quality in vegetable oil seed crop.

Groundnut farmers mostly apply NPK nutrients to increase yield. However, nowadays various ways are being practiced to overwhelm problems encountered by using chemical fertilizers alone. When concerning cost of commercial chemical fertilizers as well as human and soil health, locally available organic manure can be used to enhance soil fertility and crop productivity (Hamza and Abd-Elhady, 2010; Mokhtariniya and Siadat, 2011) in developing countries. Addition of organic manures to soil also improves soil physical properties (Busscher *et al*., 2010) and penetration resistance in loam soils (Alvarez *et al.,* 2009). Moreover, it contains both macro and micro nutrients. Oilseeds require high amounts of both macro and micro nutrients because they are energy-rich crops (Veeramani and Subrahmaniyan, 2011). Groundnut plants need high level of calcium during pod filling stage to obtain better yield of quality kernels and its deficiency directs to unfilled pods (Reddy, 2006). Gypsum is readily available source of calcium as well as sulfur for crops and sulfur is necessary for improving the oil content in groundnut (Rao *et al*., 2013). Hence, this experiment was done to study the effect of combined use of chemical fertilizers, farmyard manure (FYM) and gypsum on yield and yield components of groundnut.

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Materials and methods

The experiment was conducted under rain fed conditions from 2012 - 2013 to find out the effect of combined use of chemical fertilizers, farm yard manure (FYM) and gypsum on yield and yield components of groundnut at the experimental station of the eastern region in Sri Lanka, which is located at $7^{o}43'$ N and $81^{o}42'$ E. The mean rainfall ranged from 80- 300 mm during the growing season of groundnut. The average minimum and maximum temperatures were $24^{o}C$ and $31^{o}C$, respectively and the average relative humidity ranged from 73% - 85%.

Soil and manure analysis

The type of soil at the experimental site was sandy regosol. Before planting, soil samples at a depth of 0-20 cm were collected to determine some properties of soil. The field soil has 6.4 pH, 26.2 µS/cm electric conductivity, 0.35% organic matter, 6.6 µg/g nitrogen, 0.06 meq/100 g potash, 37.2 µg/g phosphate, 1.7 meq/100g calcium and 6.5 µg/g sulfate. Similarly some chemical compositions of air dried farm yard manure applied were determined. It contained 1.11% N, 0.80 % K_2O, 0.12% P_2O_5 and 0.41% Ca. Analysis was carried out on dry basis except pH and electric conductivity.

Experimental design

The experiment was laid out in a randomized complete block design with three replications. There were nine treatments including absolute and typical controls as given in Table I. Plot size was 4.86 m^2.

Table I. Treatments used in this experiment

Treatment code	Total nutrients applied to soil		
	NPK chemical fertilizers (Urea: TSP:MOP) (kg/ha)	Farm yard manure (t/ha)	Gypsum (kg/ha)
T1 (absolute control)	00:00:00	0	0
T2 (typical control*)	65:100:75	0	0
T3	65:100:75	0	150
T4	65:100:75	0	300
T5	65:100:75	0	450
T6	30: 50:37.5	10	0
T7	30: 50:37.5	10	150
T8	30: 50:37.5	10	300
T9	30: 50:37.5	10	450

*Typical control ie chemical fertilizers applied as recommended by the Department of Agriculture, Sri Lanka.

Agronomic practices

Groundnut seeds cv. *Indi* were obtained from the Seed production and Processing unit at the Eastern University of Sri Lanka and one seed per hill was planted at a spacing of 45 × 15 cm. Full doses of recommended NPK fertilizers (Urea:TSP:MOP@35:100:75 kg/ha) or half doses of recommended PK fertilizers (TSP:MOP@50:37.5 kg/ha) with FYM@10 t/ha were uniformly applied as basal dressing while all experimental plots except absolute control (no fertilizer application at any stage) were treated with urea@30 kg/ha and different levels (0, 150, 300 and 450 kg/ha) of gypsum as topdressing at flowering stage. Urea, TSP and MOP contain 46%N, 45% P_2O_5 and 60% K_2O respectively whereas gypsum consists of 22% Ca and 17% S. FYM were applied two weeks before planting and it was thoroughly mixed with the soil. Weeding was done manually and plants were irrigated with ground water to sustain the field capacity. Irrigation was stopped two weeks before harvesting.

Data collection

The randomly selected ten plants from each experimental plot were uprooted at 110 days after planting and the plants were separated into pods, shoot and roots. Numbers of pods and seeds per plant were counted. Subsequently, they were dried under sunlight for three days to record constant dry weights. Dry weights (g) of pods, seeds, shoot and roots per plant were measured and 100 seed weight (g) was taken. Shelling (%), pod yield (t/ha), seed yield (t/ha), and harvest index (HI) were calculated.

Statistical analysis

The collected data were subjected to analysis of variance using statistical analysis system software (SAS Institute, Cary, North Carolina, USA). Treatment mean separations were done using the Tukey's honesty significant difference test at 5% significant level.

Results and discussion

Pod and seed numbers

There was a significant difference ($P<0.01$) in an average number of pods per plant among the treatments (Table II). It was remarkably lower value (10.67) in unfertilized treatment ie absolute control (T1) than treated plants. This is in line with finding of Munda *et al.* (2004), who reported that num

Table II. The numbers and weights of pods and seeds per groundnut plant in each treatment.

Treatments	Pod number per plant	Seed number per plant	Air dried pod weight (g) per plant	Air dried seed weight (g) per plant
T1	10.67 ± 0.33^{b}	16.00 ± 0.50^{d}	11.47 ± 0.48^{c}	05.91 ± 0.35^{d}
T2	21.83 ± 0.88^{a}	29.00 ± 0.29^{c}	23.97 ± 0.67^{b}	15.36 ± 0.29^{bc}
T3	23.00 ± 0.29^{a}	31.83 ± 1.09^{bc}	25.72 ± 1.12^{ab}	16.88 ± 0.55^{abc}
T4	25.00 ± 1.04^{a}	32.00 ± 0.29^{bc}	28.38 ± 0.41^{a}	18.72 ± 0.34^{a}
T5	24.67 ± 0.17^{a}	31.17 ± 1.30^{bc}	27.32 ± 1.30^{ab}	17.80 ± 0.67^{ab}
T6	22.00 ± 0.76^{a}	32.67 ± 0.88^{abc}	23.12 ± 1.23^{b}	14.98 ± 0.42^{c}
T7	22.67 ± 0.44^{a}	35.17 ± 1.09^{ab}	25.03 ± 1.14^{ab}	16.29 ± 0.85^{abc}
T8	24.67 ± 0.73^{a}	36.67 ± 0.88^{a}	26.37 ± 0.56^{ab}	17.02 ± 0.53^{abc}
T9	25.00 ± 0.58^{a}	32.83 ± 1.01^{abc}	27.21 ± 0.40^{ab}	17.62 ± 0.47^{ab}
F test	**	**	**	**
CV %	5.28	4.85	5.98	5.46

Values are means ± standard error of three replications. Means followed by the same letter are not significantly different from each other at 5% significant level according to Tukey's honestly significant difference test at 5% significant level.

ber of pods per groundnut plant was increased by 20:60:40 kg/ha $N:P_2O_5:K_2O$ application as compared to control. In the present study, the number of pods was affected by the gypsum application (0-450 kg/ha) however it was statistically similar ($P>0.05$) among the treated plants and ranged from 21.83 to 25.00. The highest average number (36.67) of seeds per plant was obtained from NPK fertilizers + FYM + 300 kg/ha gypsum (T8) and also the effect of T8 was considerably ($P<0.05$) high as compared to the result of either NPK fertilizers alone (T2 as typical control) or NPK fertilizers with gypsum (T3-T5). The average number of seeds per plant was 29.00 in T2 while T4 and T5 had 32.00 and 31.17 respectively.

Pod and seed weights

The mean weight of pods per plant was significantly affected ($P<0.01$) by nutrients applied to the plants (Table II). There was noticeable variation ($P<0.05$) in pod weight between gypsum treated and untreated plants. Significantly highest pod weight (28.38 g) was recorded with NPK fertilizers and 300 kg/ha gypsum (T4) which, remarkably differed from T1, T2 and T6 but the other treatments were statistically similar with T4. This is proved by the result which showed increase in pod weight by gypsum application. In term of mean seed weight, there was a significant difference ($P<0.05$) between unfertilized and fertilized treatments. Seed weight ranged from 14.98 g (T6) to 18.72 g (T4) among the fertilized treatments. Treatment T9 (with gypsum) had remarkable effect ($P<0.05$) on seed weight than T6 (without gypsum). It was 17.62 g in T9 while T6 had 14.98 g. The weights of pods and seeds per plant tended to increase about 18% and 22% respectively with higher dose of gypsum ie 300 kg/ha gypsum (T4) in NPK fertilizers + gypsum treatments. It had significantly ($P<0.05$) higher values than typical control (NPK fertilizers alone). Application of gypsum at 250 kg/ha enhanced the pod yield of groundnut than control ie without gypsum treatment (Rao and Shaktawat, 2005; Thilakarathna *et al.,* 2014).

100 seed weight

The average one hundred seed weight was statistically similar ($P>0.05$) among the treatments except T1 (Table III). Application of gypsum at 150 or 300 kg/ha slightly increased the one hundred seed weight over control (T2) and the highest seed weight was obtained at 300 kg/ha gypsum application. The lowest weight was recorded in T1 which had an average of 43.77 g. The one hundred seed weight ranged from 51.17 - 53.42 g among the treated plants.

Shelling percentage

The average shelling % exhibited a significant difference ($P<0.01$) among the treatments (Table III) however remarkable variations ($P>0.05$) were not noted by the gypsum treatments. The lowest shelling % was recorded in absolute control (T1) which had 51.5% and it was significant from other treatments. Among the fertilizers treated plants, high shelling percentage was in T4 (66.05%) and low in T2 (64.13%) i.e., in typical control. Certain amount of gypsum

Table III. The 100 seed weight, shelling %, crop residue weight and plant biomass of groundnut in each treatment

Treatments	100 seed weight (g)	Shelling %	Crop residue (g) per plant	Biomass (g) per plant
T1	43.77 ± 0.71^{b}	51.50 ± 1.05^{b}	14.22 ± 0.73^{b}	25.68 ± 1.21c
T2	52.03 ± 0.61^{a}	64.13 ± 0.62^{a}	19.83 ± 1.03^{a}	43.80 ± 1.14^{b}
T3	53.35 ± 0.71^{a}	65.72 ± 1.02^{a}	19.93 ± 0.55^{a}	45.65 ± 1.58^{ab}
T4	53.42 ± 0.65^{a}	66.05 ± 0.42^{a}	20.50 ± 0.34^{a}	48.88 ± 0.65^{a}
T5	53.17 ± 0.61^{a}	65.27 ± 1.48^{a}	21.05 ± 0.82^{a}	48.37 ± 0.54^{a}
T6	52.27 ± 1.08^{a}	65.04 ± 2.53^{a}	19.59 ± 1.03^{a}	42.71 ± 1.08^{b}
T7	52.68 ± 0.92^{a}	65.95 ± 0.46^{a}	20.63 ± 0.55^{a}	45.33 ± 1.67^{ab}
T8	52.90 ± 0.83^{a}	64.54 ± 0.65^{a}	22.20 ± 1.03^{a}	48.37 ± 0.56^{a}
T9	51.17 ± 0.89^{a}	64.75 ± 1.65^{a}	21.33 ± 1.67^{a}	48.54 ± 1.66^{a}
F test	**	**	**	**
CV %	2.81	3.54	7.32	4.24

Values are means ± standard error of three replicates. Means followed by the same letter are not significantly different from each other at 5% significant level according to Tukey's honestly significant difference test at 5% significant level.

application enhanced the shelling % in groundnut. Application of full dose of NPK fertilizers with gypsum beyond 300 kg/ha did not improve the pod and seed weights as well as shelling% in groundnut. On the other hand, Prabhakaran *et al.* (1998) reported that application of 17:34:54 kg/ha NPK fertilizers + 500 kg/ha gypsum + 12.5 kg/ha micronutrient mixture increased the yield of groundnut. It may be probably due to the addition of micronutrients to the soil. In NPK fertilizers + 10 t/ha FYM + gypsum treatments, increasing gypsum level upto 450 kg/ha remarkably enhanced the seed yield about 18% as compared to NPK fertilizers + 10 t/ha FYM treatment (T6).

Plant biomass

A significant effect on mean crop residue was noticed (P<0.01) between untreated and treated fertilizers (Table III). Crop residue included shoot and root weights but excluding shell weight which can be ignored. It ranged from 14.22 g (T1) to 22.20 g (T8). Gypsum treatment did not exhibit any remarkable impact on crop residue. On the other hand, average plant biomass was markedly varied (P<0.05) by the gypsum application (300-450 kg/ha) and its weight was about 48 g. No significant difference was showed between gypsum untreated and treated plants at 150 kg/ha which had plant biomass within a range of 42-45 g. Positive effects on crop residue and plant biomass of groundnut were observed due to the gypsum application. Addition of FYM with NPK fertilizers improved physical, chemical and biological properties of soil for better plant growth (Deshmukh *et al.*, 2005).

Pod yield

There was a remarkable variation (P<0.01) in an average pod yield among the treatments (Table IV). It was slightly influenced by the gypsum application with NPK fertilizers alone (T3-T5) or in combination with FYM (T7-T9). The highest pod yield (4204.44 kg/ha) was recorded in T4 (NPK fertilizers + gypsum at 300 kg/ha), which was statistically similar with the other gypsum treated plants. The pod yield increased considerably with increase of gypsum level from150 kg/ha to 450 kg/ha in NPK fertilizers + FYM + Gypsum treatments. The lowest yield (1698.77 kg/ha) was noticed in T1 i.e. in absolute control. Gypsum provides calcium and sulfur for groundnut crop and sulfur is an important element for protein and oil synthesis (Rao *et al.,* 2013). Groundnut yield increased with Zn, B and S application to soil (Chitdeshwari and Poongathai, 2003). Adequate quantities of macro and micro nutrients are necessary for obtaining better pod yield of groundnut.

Seed yield

In groundnut, seed yield enhanced significantly (P<0.01) with the application of fertilizers (Table IV). Treatment T4 (65:100:75 kg/ha NPK fertilizers + 300 kg/ha gypsum) gave highest seed yield (2777.28 kg/ha) compared to the other treatments and the lowest value (875.05 kg/ha) was recorded in T1. Treatment T4 showed significant effect (P<0.05) on seed yield as compared to T2 (65:100:75 kg/ha NPK fertilizers) which gave 2276.05 kg/ha. There was also a remarkable difference between T6 (30:50:37.5 kg/ha NPK fertilizers + 10 t/ha FYM) and T9 (3050:37.5 kg/ha NPK fertilizers + 10

Table IV. Pod yield, seed yield, and harvest index in each treatment.

Treatments	Pod yield (kg/ha)	Seed yield (kg/ha)	HI
T1	1698.77 ± 71.22^{c}	875.05 ± 51.36^{d}	23.04 ± 0.38b
T2	3551.11 ± 99.08^{b}	2276.05 ± 43.50^{bc}	35.11 ± 1.00^{a}
T3	3810.37 ±166.05^{ab}	2501.93 ± 81.64^{abc}	36.99 ± 0.10^{a}
T4	4204.44 ± 60.77^{a}	2777.28 ± 49.94^{a}	38.35 ± 0.20^{a}
T5	4046.91 ±193.01^{ab}	2637.53 ± 98.96^{ab}	36.79 ± 0.98^{a}
T6	3425.19 ±182.84^{b}	2219.75 ± 62.75^{c}	35.13 ± 1.35^{a}
T7	3658.27 ±169.21^{ab}	2413.83 ±126.46^{bc}	35.91 ± 0.55^{a}
T8	3906.17 ± 83.40^{ab}	2521.98 ± 78.79^{abc}	35.08 ± 1.43^{a}
T9	4031.11 ± 58.56^{ab}	2609.88 ± 69.68^{ab}	36.31 ± 0.42^{a}
F test	**	**	**
CV %	5.98	5.49	4.19

Values are means ± standard error of three replicates. Means followed by the same letter are not significantly different from each other at 5% significant level according to Tukey's honestly significant difference test at 5% significant level.

t/ha FYM + 450 kg/ha gypsum). Seed yields in T6 and T9 were 2219.75 kg/ha and 2609.88 kg/ha, respectively. Furthermore, it was noted that no significant variation was observed in seed yield between T2 and T6.

In reduced dose (30:50:37.5 kg/ha) of NPK fertilizers + 10 t/ha FYM + gypsum treatments, higher dose (450 kg/ha) of gypsum treatment (T9) gave 2609.88 kg/ha seed yield followed by 300 kg/ha gypsum application (T8) which had 2521.98 kg/ha seed yield and both values were statically similar. Gashti *et al*. (2012) mentioned that highest pod and seed yield were achieved from 90 kg calcium through gypsum. Calcium and sulphur are significant soil nutrients for groundnut crop and sulphur deficiency is common on sandy textured soils (Sigh *et al.,* 1993). As a result, combined fertilization leads to balanced nutrient supply and improved soil fertility over application of inorganic or organic source alone (Ayeni and Adetunji, 2010).

Harvest index

All fertilized treatments significantly increased ($P<0.05$) pod and seed numbers, 100 seed weight, pod and seed weights, shelling %, plant biomass, pod yield, seed yield and harvest index compared to unfertilized treatment where the type of soil at the site is sandy regosol which has relatively low organic carbon, total nitrogen and potash. Yield and yield components were increased with the addition of gypsum to all the NPK fertilized plots. Highest harvest index (HI) was 38.35% in NPK fertilizers with 300 kg/ha gypsum treatment (T4) while absolute control (T1) gave significantly ($P<0.05$) least value of HI from the fertilizers treated plants in which HI ranged from 35.11% to 38.35% (Table IV). Further, it was observed that harvest index was statically similar in the fertilized treatments.

Conclusion

The results reveal that significant increase in seed yield (2777.28 kg/ha) was noted in full dose (65:100:75 kg/ha) of NPK fertilizers with 300 kg/ha gypsum treatment than full dose of NPK fertilizers alone (typical control) which had 2276.05 kg/ha seed yield. Application of reduced NPK fertilizers with FYM + 300 kg/ha gypsum resulted to 2521.98 kg/ha seed yield which was statically similar to that of the typical control. All gypsum treatments had also positive effect on yield components and 300 kg/ha gypsum with full dose of NPK fertilizers or reduced dose of NPK fertilizers + 10 t/ha FYM were the optimum level for obtaining the higher pod and seed yields of groundnuts.

Acknowledgement

This research was carried out through the financial support under National Agricultural Research Plan (NARP) 2011-2015 from Sri Lanka Council for Agricultural Research Policy (SLCARP), Sri Lanka.

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Received: 08 December2015; Revised: 12 April 2016; Accepted: 24 April 2016.