Seed Res., Vol. 40(1): 6-11 June 2012

Influence of nitrogen and sulphur on seed yield and quality of groundnut (*Arachis hypogaea*)

ANTENEH GIRMA, NIGUSSIE DECHASSA AND R.P.S. TOMER

School of Plant Sciences (Seed Science and Technology), Haramaya University, Ethiopia

tomer.rpstomer@gmail.com

ABSTRACT Field trial and laboratory experiment were conducted in the experimental farm station Babile, and Seed Science Technology Laboratory, Haramaya University, respectively during the summer season of 2010, to investigate the response of three groundnut (*Arachis hypogaea* L.) cultivars (Roba, Weren-962 and Oldhale) to five levels of nitrogen and sulphur combinations (0:0, 10:0, 0:9, 20:8, 30:27 kg ha^{-1}). Roba showed highest seed yield (1148.8 kg ha^{-1}), 100-seed weight (69.9 g) and vigour index II (708), whereas Werer-962 gave the highest number of pods/plant (132.3) and speed of germination (22.2). Variety Oldhale showed poor response to different rates of nitrogen and sulphur application except for standard germination and vigour. Nitrogen and sulphur @20 + 18 kg ha^{-1} resulted in the highest yield and yield components in variety Roba and Werer-962. However, significantly reduced standard germination, vigour indices and speed of germination were observed in this variety. Results demonstrated enhanced yield of groundnut seed in response to increased levels of combined nitrogen and sulphur application. The groundnut varieties had responded differently to the combined application of the two nutrients. It could be concluded that Roba, as noticed from its higher performance with respect to various growths and phenological characters including its response to nitrogen and sulphur application, may be the best variety under Babile's agro-ecology and the impact of the presence of different nitrogen and sulphur rate for seed and grain production.

Key words: Groundnut, plant nutrition, seed yield, seed quality, nitrogen, sulphur

Groundnut, not only an important food and cash crop in the semi-arid areas of the eastern, western and north-western parts of Ethiopia [1], is also one of the three economically important oil seed crops including nough (*Guizota abyssinica* L.) and sesame (*Sesamum indicum*) in Ethiopia [2]. In 2009/10 the total area under groundnut production was estimated to be 41,578.7 ha with a total production of 46,424.8 tones and ranks the second most important low land oilcrop with an average yield of 1.11 t ha^{-1} [3]. However, the average national yield of groundnut in Ethiopia is significantly lowers than it's potentially achievable over 2 t ha^{-1} [1, 4].

There are many factors that can narrow down the gap between potential and farm level yield. Among them, use of quality seed is the most important one [5]. Production of high quality seed is possible only by adopting scientific, cultural and improved agronomic management practices. Among several agronomic and management practices, the supply of nutrients to the plant plays an important role for increased yield and quality of seeds. In Ethiopia low soil fertility is one of the factors limiting the productivity of crops [6]. Studies have indicated that more than 429 thousand tones of nutrients are removed from the soil every year by the annual crops [7]. The farmers of Ethiopia generally are producing groundnut without using proper nutrient application. Some of them are using only Urea, DAP but other nutrients like Sulphur are not being used.

Received : March 2012 Revised : May 2012 Accepted : June 2012

Groundnut requires more sulphur than other crops [8]. Apart from the influence of S on yield formation, the S nutrition has an impact on the quality of the crop. Field studies showed that the yield attributes like number of pods/plant, 100-seed weight, number of seeds/pod, etc. show positive response on chickpea and sarsoon [9]. Nitrogen metabolism is strongly affected by the S status of the plant, since the central role of both S and N is in the synthesis of proteins. There were limited research on the effects of nitrogen and sulphur on groundnut seed production in Ethiopia. Therefore the current investigation was to study the response of three groundnut cultivars to the combination of N and S fertilizers.

MATERIALS AND METHODS

The seeds of groundnut (*Arachis hypogaea* L.) were obtained from plant science section, Haramaya University, Haramaya during the summer season of 2010, to study the effect of N/S fertilizer combinations (0:10, 10:0, 0:9,. 20:18, 30:27 kg ha^{-1}) on three groundnut cultivars Roba (later-maturing, large-seeded). Before planting, soil samples were taken from the experimental site and analyzed [10].

The experiment was laid out in a randomized complete block design (RCBD) in a factorial arrangement and replicated three times. Treatments were assigned to each plot randomly. The size of each experimental plot was 7 m^2 (2.8 m x 2.5 m) accommodating eight rows of plants spaced at 35 cm (between rows) and 25 cm between plants spaces of 70 cm between the plots and 1 m between blocks were maintained. Urea as a source of nitrogen was applied in two splits, ½ at the time of planting and the other ½ before flowering time. The full doses of potassium sulphate as a source of sulphur were applied at the time of sowing. Data were recorded on the following: seed yield/ha. 100-seed wieght, number of pods/plant, germination percentage, vigour index and speed of germination. The seed quality parameters were studied before sowing and after harvesting the crop.

Number of pods/plant: Determined by counting the total number of pods present on five randomly sampled plants during harvest to calculate the mean pods/plant.

Seed yield: Plants from each treatment in each replication were harvested separately and were dried under shed. The total pod yield obtained from each plot was recorded. Pod yield was computed and expressed in kg/ha.

100-seed weight: Random sample of 100-seeds were taken from the harvested bulk in replicates and weighed.

Standard germination test: Seed germination was tasted at 25^0C for 10 days [11] with two replicates of 200 seeds for each treatment. Seeds were planted in plastic boxes filled (up to 3 cm) with moist fine sands (0.05 to 0.85 mm) and placed in an incubator for germination.

Vigour index: For each treatment, two vigour indices were calculated. Seedling Vigour Index 1 was calculated by multiplying the standard germination with the average of the sum of shoot length and root length (mm) after 10 days of germination. Vigour Index II was calculated by multiplying the standard germination with mean seedling dry weight [12].

Speed of germination: It was measured using the procedure followed by Maguire [13]. A refinement of the above technique is to make germination counts every day until germination is completed. An index of the speed of germination was then calculated by adding the quotients of the daily counts divided by the number of days to seed germination.

Statistical analysis: The data collected on different parameters under the experiment were statistically analyzed to obtain the level of significance using the General Linear Model (GLM) of the SAS system for windows, Version 9 [14]. Least significant difference test (LSD) at 5% level of probability was used to delineate the significant differences between and/or among treatment means.

RESULTS AND DISCUSSION

The soil of the experimental site was sandy in texture; its physical and chemical properties were presented (Table 1).

Number of pods/plant: The main effects of both variety and N/S fertilizer were highly significant

Table 1. Some physical and chemical properties of a representative soil samples in the experimental site before sowing

Soil property	Value*
pH (H_2O)	6.50
Organic matter (%)	1.90
Total nitrogen (%)	0.93
K (me/100 g)	0.26
Available phosphorus (ppm)	4.60
Caption exchange capacity (me/100 g)	33.20
Avaiable sulphur (ppm)	4.005
Organic carbon (%)	1.10

*Each value represents the mean of three replications

on the number of pods/plant.

For variety Werer 962, the number of pods/plant were increased significantly with the increase in the application of combined levels of nitrogen and sulphur. The significantly higher number of pods/plant was attained with the combined application of 20 kg N + 18 kg S ha^{-1}. The significantly lowest number of pods/plant was obtained at the sole sulphur application of 0 kg N + 9 kg S ha^{-1}. The differences in the numbers of pods/plant between the two combined levels of the nutrients amounted to about 32%. The numbers of pods/plant for the other combined levels of nitrogen and sulphur were in statistical parity. For variety Roba the number of pods/plant continued to increase with the increased rate of both nitrogen and sulphur. However, similar to the number of pods/plant were recorded with the variety Werer 962, the highest numbers of pods/plant of this variety were recorded with 20 kg N + 18 kg S ha^{-1}, whereas minimum number of pods were recorded from control which was at par with sole S application. This variation amounted to about 25%. For variety Oldhale by increasing the levels of combined application of nitrogen and sulphur had decreased the number of pods/plant, with the height being attained at the control treatment and the lowest at the highest level of the combined rates of the nutrients, *i.e.* 30 kg N + 27 kg S ha^{-1}, compared to the number of pods produced per plant by plants grown in the control treatment, the number of pods/plant produced by plants grown at the combined levels of 30 kg N + 27 kg S ha^{-1} was reduced by about 14%. The results were almost similar with Jamal [15] who found a significant increase in the number of pods/plant due to interactive application of both N and S. The significant increase in the number of pods/plants with increase in the combined rate of nitrogen and sulphur may be attributed to greater utilization of assimilates into the pods and ultimately increased number of pods/plant as suggested by Ahmed *et al.* [5].

Seed yield: Data regarding seed yield/ha is presented (Table 2). Observation showed that both variety and N/S had highly significant effects on the seed yield of groundnut. There were also significant interactive effects of the two factors on this parameter. The lowest seed yield (375.6 kg ha^{-1}) was produced from variety Werer-962 in the control, whereas the highest one (1148.8 kg ha^{-1}) was produced with the combination 20 kg N + 18 kg S ha^{-1} in Roba. Werer-962 showed higher (155%) seed yield as compared with variety Roba which showed only 37% increase. Moreover, further increase of fertilizer to the level of 30 kg N + 27 kg S ha^{-1} increased seed yield only by 138% and 9.3%, respectively. This result was supported by that of Dev and Kumar [16] who reported the presence of a very narrow range N:S ratio for optimum yield of soybean, and unbalanced fertilizer use adversely affects crop production. On the contrary, variety Oldhale had showed no significant response to N/S application, in conformity with the results of Maynard *et al.* [17], who also reported the occurrence of differences in response to N:S ratio among rape-seed varieties. Increase in seed yields due to N/S application occurred primarily from the resultant increase in yield attributes such as number of pods/plant and 100-seed weight (Table 2). In agreement with the present finding. Walker and Booth [18] reported that the maximum seed yield obtained when S and N applications were balanced. In this regard application of 20 kg N + 18 kg S ha^{-1} was found to be the optimum.

100-seed weight: Data showed that both variety and N/S had significant effects on 100-seed weight of

Table 2. Interactive effect of groundnut varieties and N/S application on seed yield and seed quality

Variety	Applied N + S (Kg ha^{-1})					Mean
	0+0	10+0	0+9	20+18	30+27	
1. No. of pods/plant						
Werer-962	28.8	27.0	24.5	32.3	29.5	28.4
Roba	23.3	27.3	24.8	29.2	27.2	26.3
Oldhale	29.1	26.7	26.1	27.7	25.5	27.0
Mean	27.1	27.0	25.1	29.7	27.4	
LSD (0.05) P X N = 2.67						
2. Seed yield						
Werer-962	375.6	631.0	586.6	957.5	894.5	750.2
Roba	873.3	798.7	654.9	1148.9	916.0	871.1
Oldhale	721.2	548.6	622.1	580.1	607.0	615.7
Mean	746.7	659.4	621.2	895.4	805.8	
LSD (0.05) P X N = 225.7						
3. 100-seed weight						
Werer-962	46.9	57.4	43.4	60.4	59.4	53.5
Roba	52.9	69.9	59.4	59.8	68.7	62.1
Oldhale	52.6	63.1	54.1	56.5	63.0	57.9
Mean	50.8	63.4	52.3	58.9	63.7	
LSD (0.05) P X N = 3.84						
4. Seed germination (%)						
Werer-962	62.5	63.5	50.0	48.5	62.0	57.3
Roba	61.5	54.0	64.0	54.0	65.0	59.7
Oldhale	41.5	73.5	54.5	51.5	45.0	53.2
Mean	50.8	63.6	56.1	51.3	57.3	
LSD (0.05) P X N = 9.94						
5. Vigour index-I						
Werer-962	1524.5	1682.5	1350.5	1236.5	1576.0	1473.8
Roba	1531.5	1311.5	1479.0	1216.0	1610.5	1429.6
Oldhale	946.5	2026.5	1296.5	1106.5	1156.5	1306.5
Mean	1334.1	1673.6	1375.4	1186.1	1447.5	
LSD (0.05) P X N = 248.9						
6. Vigour index-II						
Werer-962	515.5	584.5	440.0	516.5	595.0	530.3
Roba	513.5	440.0	582.0	513.0	708.5	551.5
Oldhale	446.0	614.0	482.5	450.5	375.5	473.7
Mean	491.7	546.0	501.5	493.3	559.8	
LSD (0.05) P X N = 90.88						

the groundnut varieties. In addition, there was also a highly significant interactive effect of the two factors (Table 2). There were remarkable increase in 100-seed weight among groundnut varieties in response to the increased levels of combined nitrogen and sulphur application. Variety Roba and Oldhale did show 32%, 20% increase due to application of N fertilizer (10 kg/ha). However, the values were in statistical parity with the values obtained at the maximum N/S application (30 kg N +27 kg S ha^{-1}). Werer-962 showed 29% increased in response to the application of 20 kg N +18 kg S ha^{-1} over control. In general increased 100-seed weight in all varieties. However, application of 0 kg N + 9 kg S ha^{-1} depressed the 100-seed weight. Similar results have been reported by Jamal *et al.* [15]. These results did indicated that both nitrogen and sulphur play important role in seed development and hence there was increase in seed size.

Standard germination: There were significant main effects of variety and fertilizer on standard germination of the crop plant. There was also a highly significant interactive effect of variety and N/S application on standard germination (Table 2). Variety Oldhale with the application of 10 kg/ha nitrogen had the highest (73.5%) germination percentage followed by variety Roba (65%), the values of which were obtained from the N/S combination of 30 kg N + 27 kg S ha^{-1}. However, these values were having statistical parity with the values obtained from the control. The lowest (41.5%) seed germination was obtained from variety Oldhale with the control. Application of S @9 kg ha^{-1} imporved germination percentage of variety Roba and Oldhale [19]. However, significant reduction in germination percentage was observed from Werer-962.

These results were supported by those of Maynard *et al.* [17], who reported the occurrence of differences in response to N:S ratio among seed varieties. Oldhale was highly responsive to nitrogen and sulphur application.

Vigour index: The main effects of both variety and N/S fertilizer were significant on vigour indices. There was also a highly significant interactive effect of variety and N/S rate on Vigour indices of the groundnut crop (Table 2).

For variety Oldhale, significantly higher (2026.5) vigour index I was recorded due to N application @10 kg ha^{-1}. This result was in line with the findings of Rowarth *et al.* [20] who observed that seed vigour improved with nitrogen application. Application of S also gave significant increase (1296.5) over control. However, integrated N/S application did not improve vigour index I in Oldhale, the results showed that N/S application did not improve vigour index I of variety Roba and Werer-962. Regarding vigour index II, variety Roba gave significantly better vigour index II 30 kg N + 27 kg S ha^{-1}, closely followed by Oldhale with the application of sole nitrogen 10 kg ha^{-1}. The rest of the interactive effects were found to be non-significant in affecting vigour index II. In agreement with the present finding, relationship between nutrition and its possible influence on physiological quality were observed by Filho *et al.* [21].

Speed of germination: The speed of germination among groundnut varieties showed significant variations (Table 3). Variety, Werer-962 had the highest (22.2) speed of germination, minimum (17.1) speed of germination was recorded for variety Oldhale. The superiority of Werer-962 to Roba and Oldhale might be attributed to its smaller seed size which may be expected to imbibe water faster than the large-seeded Roba. As a result, seeds may

Tabler 3. The effect of variety and N/S aplicaiton on speed of germination

Variety	Speed of germination
Werer-962	22.2
Roba	19.7
Oldhale	17.1
LSD (0.05)	3.4
N/S (kg ha^{-1})	17.5
0/0	26.8
0/9	20.5
20/18	17.3
30/27	16.3
LSD (0.05)	4.4

germinate faster. In conformity to the present findings. Singh [22] reported that seed size was strongly correlated with days to germination and smaller seeds germinated faster than larger seeds.

Speed of germination also significantly differed in response to N/S application (Table 3). However, application of sole nitrogen 10 kg ha^{-1} resulted in a significant increase (26.8) over the control, compared with other N/S treatments. In agreement with the present finding, Lopez and Grabe [23] reported that, seeds with high N concentration germinated faster and developed into larger seedlings with higher dry matter content.

REFERENCES

1. ADUGNA W (1992). Groundnut Breeding in Ethiopia. *Proc First National Oilseeds Workshop in Ethiopia*. 3-5 December 1991, Addis Ababa Institute of Agricultural Research, Ethiopia, pp 312
2. GETNET A AND NIGUSSIE A (1992). Production and research on oilseeds in Ethiopia. *Proc National Oilseeds Workshop in Ethiopia*, 3-5 December 1991, Addis Ababa: Institute of Agricultural Research, Ethiopia, pp 312
3. CSA (Central Statistical Authority) (2010). *Agricultural Sample Survey 2009/10: Report on area and production of crops* (private peasant holdings, *meher season*). V.I. Statistical Bulletin 446. Addis Ababa, Ethiopia
4. GEREMEW T AND ASFAW T (1992). Groundnut and sesame diseases in Ethiopia. *Proc First National Oilseeds Workshop in Ethiopia*, 3-5 December 1991. Addis Ababa: Institute of Agricultural Research, Ethiopia, pp 312
5. AHMAD A, ABRAHAM G, GANDDOTRA N, ABROL VP AND ABDIN MZ (1998). Interactive effect of nitrogen and sulphur on growth and yield of rapeseed-mustard (*Brassica juncea* L) *Czern* and *Coss* and *Brassica campestris* L). *J Agron Crop Science* **181**: 193-99
6. BEGA L, GEBREMEDIHIN W, TERISSA T AND BNERKE-TSEHAI T (1994). Potato agronomy research. In: Edward Herath and Lemma Dessalegne (eds) *Proc Ethiopia*, Addis Ababa, 1-3 December 1992. Addis Ababa: Institute of Agriculture Organization, Ethiopia, pp 101-19
7. FAO (1994). Food crops intensification and integrated plant nutrition in Ethiopia plant management service, Food and Agricultural Organization of the United Nations, Rome, Italy
8. ZAMAN B, SALIM M, RAHMATULLAH AND ZIA MS (1996). Utilization of phosphorus and sulphur by maize from various organic and inorganic sources. *Pakistan Journal Soil Science* **12**: 77-80
9. TRIPATHI HC, SINGH RS AND MISRA VK (1997). Effect of S and Zn nutrition on yield and quality of chickpea (*Cicer arietinum*). *Journal of Indian Society of Soil Sciences* **45**: 123-25
10. PAGE AL, (1982). Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. Maidson, Wisconson
11. ANONYMOUS (2011). *International Rules for Seed Testing*. ISTA, Zurich, Switzerland
12. FIALA F (1987). Handbook of Vigour Test Methods. ISTA publication
13. MAGUIRE JD (1962). Rate of germination aid in selection and evaluation for seedling emergence and vigour. *Crop Sci* **2**: 176-77
14. SAS Institute (2002). The SAS System for Windows, Version 9.0 SAS Institute Inc, Cary, NC, USA
15. JAMAL A, FAZLI JS, AHMAD S AND ABDIN MZ (2006). Interactive effect of nitrogen and sulphur on yield and quality of groundnut (*Arachis hypogea* L) *Korean Journal Crop Science* **51**(6): 519-22
16. DEV G AND KUMAR V (1982). Secondary nutrients. In: Review of Soil Research in India, Part I, 12th International Congress of Soil Science, New Delhi, India, pp 342-60
17. MAYNARD DG, STEWART JWB AND BETTANYT, JR (1983). Use of plant analysis to predict sulphur deficiency in rapeseed (*Brassica napus*). *Canadian Journal of Soil Science* **63**: 387-96
18. WALKER KC AND BOOTH EJ (2003). Sulphur nutrition and oilseed quality. In: Abrol YP and Ahmad A (eds) *Sulphur in Plants*. Kluwer Academic Publishers, Dordrecht, pp 323-39
19. MAEDA JA, LAGO AA AND TELLA RD (1986). Effect of timing of NPK and fertilizer application on the quality of groundnut seeds. *Pesquisa Agropecuaria Brasileira*, **21**(9): 941-44
20. ROWARTH JS, ARCHIE WJ, COOKSON WR, HAMPTON JH, SAUNDERS CJ, SIBERSTEIN TB AND YOUND WC (1999). The link between nitrogen application, concentration of nitrogen in herbage and seed quality in perennial ryegrass (*Loilum perenne* L.) *Journal of Applied Seed Production* **17**: 1-8
21. FILHO MJ, CUSTODIO CC, CAMARA GMS, MARCOS EA AND MIRANDA RE (1994). Relationship between nitrogen sources, germination and vigour of soybean seeds. *Sciences and Agriculture, Piracicaba* **51**(2): 305-14
22. SINGH N (2009). Effect of seed size on quality within seed lot of pea and correlation of standard germination, vigour with field emergence test. *Journal of Nature and Science* **7**(4): 1545-54.