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Effect of NPK Micro-dosses on Yield, Oil and Protein of Groundnut

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Abstract

A field experiment was conducted under rain fed condition for two seasons (2011 and 2012) at two locations in North Kordofan, Sudan at Elobeid Research Station farm and Faris village, to study the effect of NPK micro dose on yield, oil and protein content of six groundnut genotypes with two NPK micro-doses, 0.0 g (control) and 0.6 g per hole. A randomized Complete Block Design with four replications was used. The characters yield and its component, oil % and protein % content were measured. The results of the combined and interaction analysis showed that there were significant (p =0.05) differences were observed for pod yield, hay yield, number of pods per plant, hundred seed weight and maturity, while differences in shelling percentage and harvest index were not significant. The high value of oil content % released by Sodiri variety with NPK treatment and the high value of protein recorded by Gibiesh with NPK treatment. Generally we concluded that the micro doses of NPK improved yield and protein of groundnut.

Keywords: peanut, North Kordofan, Sudan, *Arashis hypogaea L*

1. Introduction

Groundnuts, or peanut (*Arashis hypogaea L.),* is an important wide spread oilseed crop. Groundnut is grown in more than 100 countries over 22 million hectares in the tropical and sub-tropical parts of the world. The total annual world production of unshelled nuts amount to about 28 million tons. India, China and U.S.A produce almost 65% of the world production. Other major groundnut producing countries include Nigeria, Senegal, Sudan, Zaire and Indonesia (Osman, 2003). In Sudan, groundnut is important oil, cash export crop. Area planted in groundnut is about 0.8 million hectares with an estimated production of 0.4 million ton (Osman, 2003). The crop is grown under irrigation in the central clay plains and in the rain fed areas in the sandy soils of western Sudan (El Naim et al, 2012). The major production regions are south Darfur, North Kordofan, Gezira and Managil. These regions account for about 75% of the total production. It's grown both under intensive, high technology, irrigated agriculture and traditional methods in rain fed condition. Rain fed production account for about 84% of the total crop area and 62% of production (Mohamoud et al, 1992). Under rain fed condition, mostly, in the western region, the crop is grown on sandy soils of low fertility. Inadequate rainfall and declining soil fertility is the most limiting factor for groundnut production in these regions (El Naim and Eldouma, 2011). Most of the cultivated area in North kordofan is located in poor sandy soil under low amount and bad distribution of rain fall, added to the use of low yield genotypes (El Naim et al, 2011, Ishag, 1980, 1986). This study was under taken with an aim to study the beneficial effects of micro doses of NPK fertilizer on productivity of groundnut in sandy soil under rain-fed condition in north kordofan of Sudan.

2. Materials and Methods

2.1 Study Area

This experiment was conducted under rain fed conditions for two seasons (2011\12-2012\13), at two locations in North Kordofan State. The first location is at Elobeid Research Station farm (13-12\N and 3-14\E), while the second location is at Faris village, latitude 12.7 and longitude 30.1. General characteristics of the soil at the study locations are presented in table (1)/

Table 1. General characteristics of the soil at the study locations

Property	Elobeid	Faris
Sand (%)	97	94
Clay (%)	2.0	3.6
Silt (%)	1.0	2.4
PH (H_2O)	7.11	7.16
N (ppm)	0.025	0.036
P (ppm)	0.07	0.21
K (ppm)	0.41	0.37
Organic matter (ml/lit)	0.55	0.35
Organic carbon (ml/lit)	0.32	0.21
C.E.C	6	8.5

2.2 Design of Layout

The field experiment was laid out in Randomized Complete Block Design with 12 treatment combinations consisting of six genotypes of groundnut. Names, botanical type, origin and seed sources of these genotypes are presented in table (4). The experimental plot consisted of 6 rows, each was 5-meter long. Spacing was 60 cm between rows and 20 cm between holes, with two seeds per hole. Before sowing seeds were treated with Apronstar at a rate of 3g/kg of seeds to prevent fungal diseases and insect damage. Sowing date was at (10/July-15/July) in the first season and (13/July-17/July) in the second season.

Table 2. General description of the tested genotypes

Genotype	Branching pattern	Botanical type	Origin	Seed source
Sodiri	Sequential	Spanish	U SA	ARC, Elobeid
Gibiesh	Sequential	Spanish	Sudan	ARC, Elobeid
ICGV92121	Alternate	Virginia	ICRISAT	ARC, Elobeid
ICGV86744	Sequential	Spanish	ICRISAT	ARC, Elobeid
ICGV89171	Sequential	Spanish	ICRISAT	ARC, Elobeid
ICGV93255	Sequential	Spanish	ICRISAT	ARC, Elobeid

*ACRISAT: International Crop Research Institute for the Semi-Arid Tropic.

Application of fertilizers: Nitrogen (N), phosphorus (P) and potassium (K) fertilizers (NPK) were applied (15:15:15), at the sowing with recommended doses (0.6 gm per holes) main plot treatment and covered with soil.

Weeding: Experiments were weeded twice, after two weeks, and four weeks from sowing.

Harvesting: The crop was harvested at physiological maturity (90days after sowing). Entire plants were uprooted from the net plot area of each treatment separately and spread in the field for drying. The pods were plucked from the plants. The produce was cleaned and pod yield per plot was recorded after complete drying.

2.3 Data Collected and Measurements Made Included

2.3.1 Seed Quality parameters

(1) Oil content in groundnut pods (%)

The oil content of oven dried pods was estimated by Nuclear Magnetic Resonance (NMR) method against a standard reference sample, Soxholate method (A.O.A.C., 1975).

(2) Protein content (%) in pods:

The protein content of pods on dry weight basis was estimated by multiplying the nitrogen content of the pods with the factor 6.25(Tai and Young, 1974) and expressed in percentage.

2.3.2 Yield and Yield Components

The tagged plants for growth studies were utilized for recording the observations on the following yield components, at harvest.

(1) Number of pods / plant

The total number of pods produced per plant was counted in all the ten randomly selected plants and average number was worked out.

(2) Hundred seed weight (g)

Samples of 100 seeds were taken at random from the produce of each net plot and their weight was recorded.

(3) Shelling percentage

From each net plot of clean pods were weighed and seed obtained after shelling. Shelling percentage was worked out by dividing seeds weight by pod weight and expressed in percentage.

(4) Pod yield (kg/ha): Pod yield (kg/ha): Calculated by using the following formula

$$\textbf{Pod yield (kg /ha)} = \frac{\textbf{Pod yield (kg)} \textit{ of plot}}{\textbf{Harvest plot area (m2)}} \times 10000$$

(5) Harvest index (HI): Harvest index was determined by using the following formula:

$$\text{Harvest index} = \frac{\text{Economical Yield (pod yield)}}{\text{Biological yield (Hay yield + pod yield)}} \times 100$$

2.3.3 Statistical Analysis and Interpretation of Data

The data collected from the experiment at different growth stages were subjected to statistical analysis as described by Gomez and Gomez (1984). The level of significance used in F and t test was p=0.05. Critical difference values were calculated where the F test was significant. Single and combined analyses of variance were carried out using MSTAT- C computer program.

3. Results and Discussion

3.1 Oil Content of Treatments

The data pertaining to the oil yield are presented in Table (3). High significant differences observed among genotypes and NPK treatments to the oil content, the high value of oil content % released by Sodiri variety with NPK treatment and the lowest by ICGV92121 without treatment. Hameed Ansari et al. (1993) reported that increasing fertilizer dose up to 50:75:30 NPK increase seed yield and oil content of groundnut. Intodia et al. (1998) reported that application of 60 kg P2O5 significantly increased number of pods per plant, shelling percentage, pod yield, haulm yield, and harvest index and oil yield of groundnut. Dwivedi *et al*. (1993), reported that Oil content ranged from 33.6 to 54.95%. The mean oil content of Virginia types was slightly higher (49.7%) than the Spanish types (47.3%). The previous composition studies in groundnut reported Virginia varieties had higher oil content than Spanish types. Oil content ranged from 33.6 to 54.95%. The mean oil content of Virginia types was slightly higher (49.7%) than the Spanish types (47.3%). The previous composition studies in groundnut reported Virginia varieties had higher oil content than Spanish types, which is comparable with the present study. Jain *et al.* (1990) also reported that potassium applied during pod development stage increased the oil content in groundnut.

3.2 Protein Content % of Treatments

Protein content % of genotypes and treatments showed in Table (3). Significant differences were observed, high value gives by Gibiesh with treatment and the lowest by ICGV 92121without treatment. Mean of genotypes without treatment 25% and 26.2 with NPK treatment. Crude protein of seed ranged from 18.92 to 30.53%. Seed protein content of most of the cultivars was higher than cowpea which contains about 24% seed protein (IITA, 1989). Cowpea and groundnut are the major protein sources to the poor and rural dwellers. Broni fufuo had the highest crude protein content (30.53%) while Sinkazie had the least (18.92%). Burhan and Hago, (2000) and El Shebiny, (2006) reported that phosphorus had essential role in protein formation, photosynthesis, nucleic acid structure and fatty acids. El-Habbasha *et.al*., (2005) showed that increasing P levels increased oil, protein, and

phosphorus contents of groundnut.

Table 3. Effect of NPK on seed size ( ) and oil and protein percentage groundnut

Genotypes	Without NPK treatment			With NPK treatment		
	Seed size	Oil %	Protein %	Seed size	Oil %	Protein %
1-ICGV92121	0.47	43	22	0.50	50	24
2-ICGV86744	0.34	47	25	0.34	55	26
3-ICGV93255	0.34	49	23	0.35	49	23
4-ICGV89171	0.41	48	24	0.47	56	26
5-Soderi	0.33	50	29	0.33	57	28
6-Gibiesh	0.34	46	27	0.36	48	30
Mean	0.37	47	25	0.39	53	26
SE ±	0.001**	1.2**	0.73**	0.001**	1.2**	0.73**
C.V	7.9	17.6	6.4	7.9	17.6	6.4

3.3 Effect of NPK Micro Dosing on Yield and Its Components

Effect of NPK micro-dosing on Yield and yield components of the tested genotypes and NPK treatment are shown in Table (4 and 5) and figure (1). Significant ($p \leq 0.05$) varietal differences were observed for pod yield, hay yield, number of pods per plant, hundred seed weight and maturity, while differences in shelling percentage and harvest index were not significant. Pod yield, hay yield, hundred seed weight, number of pods per plant and maturity were significant. The highest pod yield of 526, 498 and 472kg/ ha were recorded by ICGV86744 without NPK treatment, ICGV86744 with NPK treatment and Gibiesh with NPK treatment respectively. The lowest yield of 273 kg/ ha was recorded by Sodiri. ICGV86744 cultivar without NPK treatment recorded the best hay yield 786 kg and Gubiesh with NPK treatment 754 kg and the lowest Sodiri without NPK treatment 419 kg. Hundred seed weight of all genotypes, except ICGV92121, ranged between 35 and 38 g. ICGV92121 recorded best 100 seed weight of 41g. The widely grown cultivars i.e., Sodiri and Gubiesh recorded almost similar 100 seed weight by treatments and without. Differences in number of pods per plant, number of seeds/pod and shelling out-turn were slight. Maturity among genotypes ranged from 81 to 85%. The highest maturity was recorded by ICGV86744 by NPK treatment, while the lowest was recorded by ICRISAT line ICGV92121without NPK micro-dosing. Differences in harvest index were slight and not significant. Harvest index of all genotypes ranged between 38 and 41 %. The highest by ICGV92121 without NPK treatment and lowest harvest index were reported by Sodiri with NPK treatment. Abdelrahman *et. al* (2011) they are reported that Micro-dosing of 0.3, 0.6 and 0.9 g fertilizer per hole increased groundnut pod yield across the three years by 36.7, 67.6 and 50.8% respectively compared to the control. Studies carried out by Abdalla (1999), showed that the mean pod yield of ICRISAT lines was 500 kg/ha and 570 kg/ha for the released varieties, shelling percentage was 65 % in ICRISAT lines and 68 % for the released varieties, hay yield was 2000 kg/ha for ICRISAT lines and 1950 kg/ha for the released varieties, hundred seed weight ranged from 32 to 37 % in ICRISAT lines and 32 for the released cultivars. Significant increase in pod yield of groundnut was observed at a fertilizer level of 30:60:30 kg NPK ha-1 and increase in yield was 30 per cent higher than lower level of fertilizer doses (Vijaya Kumar, 1997). Kandil *et al*. (2007) reported that the increasing nitrogen levels increased number of leaves, stems, total pods and pod dry weight per plant, number of pods per plant, weight of pods per plant, number of seeds per plant, weight of seeds per plant, 100-pod weight, 100-seed weight, pod yield, straw yield, seed protein content and NPK contents. However, numbers of pods per plant and seed oil content were decreased by increasing nitrogen levels. Reddy *et al.* (1992) observed considerable increase in pod as well as haulm yields with the application of 40 kg N ha-1 as compared to 20 kg N in alfisols having low availability of N. Yakadri *et al*. (1992) observed that 100 kernel weight was significantly increased with the application of 30 kg N ha-1 over unfertilized control in red sandy loam soils in Southern Telengana zone of Andhra Pradesh. Application of 40 kg N ha-1 significantly increased the number of pods per plant, kernel and oil yield by 16.6, 18.8 and 24.7 per cent, respectively (Patra *et al*., 1995). Nasr-Alla *et al.* (1998) reported that increasing the rate of PK individually or in combination increased the crop growth and yield characters. NPK fertilization combination at the rate (N, P2O5 and K2O, respectively, kg/ha) of 40, 80 and 40 (Angadi *et al.*, 1989); 40, 80 and 30 (Barik *et al.,* 1994); and 20, 60 and 40 (Purushotham and Hosmani, 1994) were the best for producing the highest peanut yield. It is a fundamental principle that raising crop yield requires both genetic and agricultural improvement. The capacity of

yield potential will be enlarged by enhanced agronomic inputs. So, under the newly reclaimed soil which mostly deficient in one or more of the essential nutrients, it should be search for the adequate perfect nutrients supplement in balanced manner. Therefore, the objective of the present investigation was; to evaluate the performance of two peanut cultivars under newly reclaimed loam sandy soil and determine their response to different combination of NPK fertilization in term of some growth characters, yields and its components. Saxena et al. (2003) reported that pod yield of groundnut could be increased with increasing levels of N and K. Similar results were also reported by Kachot et al. (2001). El-far and Ramadan (2000) indicated that application of 46.6 kg P_2O_5 and 36kg K_2O/fed gave the highest effect on yield and its attributes.

Table 4. Effect of NPK micro-doses on shelling, harvest index and 100-weight of groundnut.

genotypes	Shelling%		Harvest Index		100 seed weight (g)	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	58.3	57.8	40.7	39.9	41.4	42.8
2-ICGV86744	58.3	58.9	38.8	39.5	33.9	34.3
3-ICGV93255	54.1	60.3	41.0	40.7	34.0	34.4
4-ICGV89171	55.3	58.2	39.8	38.6	36.6	37.5
5-Soderi	57.8	58.2	40.5	37.9	32.4	32.4
6-Gibiesh	56.3	59.6	39.4	38.9	33.3	31.5
Mean	56.7	58.8	40.1	39.3	35.3	35.5
SE ±	1.01^{ns}	1.01^{ns}	1.04^{ns}	1.04^{ns}	0.28**	0.28**
C.V	7.0	7.0	32.2	32.2	3.2	3.2
Interaction	56.6^{ns}	58.5^{ns}	39.9^{ns}	39.1^{ns}	34.9**	35.7**

Table 5. Effect of NPK micro-doses on yield of pods, hay yield, yield (kg/ha) and maturity percentage of groundnut

genotypes	Pods/plant		Hay yield (kg/ha)		Pod yield (kg/ha)		Maturity %	
	Control	With NPK	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	22.6	26.6	567.6	554.3	396.2	379.6	81.0	81.3
2-ICGV86744	19.9	23.3	786.7	678.1	526.0	498.7	83.0	85.1
3-ICGV93255	19.0	21.4	623.1	703.4	430.0	461.8	82.0	84.7
4-ICGV89171	20.5	27.7	525.3	593.0	361.4	398.8	83.6	84.1
5-Soderi	20.7	27.8	419.5	500.4	272.6	322.7	83.8	84.9
6-Gibiesh	21.8	28.5	730.5	754.3	467.0	472.7	83.2	85.0
Mean	20.8	25.9	608.8	630.6	408.9	422.4	82.8	84.2
SE ±	0.93**	0.93**	31.8**	31.8**	22.6**	22.6**	0.41**	0.41**
C.V	16.0	16.0	20.5	20.5	21.8	21.8	2.0	2.0
Interaction	20.2	26.0*	607.9	633.1**	407.1	423.2*	82.1	85.0**

4. Conclusions

Based on the study results, a micro nutrient application using NPK fertilization is a key management strategy for enhancing groundnut productivity and quality on sandy soil of North Kordofan of Sudan under rain-fed.

Author Contributions

This research was undertaken by the collaborating authors. Authors Yasir , El Naim, Elgailani, Tarig and Omer Yasser and others designed the study, wrote the protocol, interpreted the data and anchored the field study,

gathered the initial data and performed preliminary data analysis. Both authors managed the literature searches and produced the initial draft. Both authors read and approved the final manuscript.

References

A.O.A.C. (1975). *Official methods of analysis* (12th Edition) William Strawetgled. Published by A.O.A.C., Washington, DC, pp. 506-508.

Burhan, H. and Hago, T. E.M. (2000). *Principles of crops production (In Arabic)*. Khartoum University Press, Khartoum.

Dwivedi SL, Nigam SN, Jambunathan R, Sahrawat KL, Nagabhushanam GVS, Raghunath K. (1993). Effect of genotypes and environments on oil content and oil quality parameters and their association in peanut (*Arachis hypogaea* L.). *Peanut Sci. 20*, pp. 84-89.

El Shebiny, G.M. (2006). *Phosphorus in the soil and the plant.* Egypt Bookshop Press. Egypt.

El-Habbasha, S.F., Kandil, A.A., Abu-Hagaza, N.S., El-Haleem, A.K.A., Khalafallah, M.A. and Behairy, T.G. (2005). Effect of phosphorus levels and some bio-fertilizes on dry matter, yield and yield attributes of groundnut. *Bulletin of Faculty of Agriculture, Cairo University, Vol. 56*, No.2, pp. 237-252.

El Naim, A. M., Eldouma, M A (2011). Effect of weeding frequency on yield and yield components of groundnut on North Kordofan of Sudan. *Bioresearch Bulletin, 5*, pp. 322-328.

El Naim, A. M.; Eldouma, M A; Ibrahim E A; Moayad, M B Z. (2011). Influence of plant spacing and weeds on growth and yield of peanut (*Arachis hypogaea* L) in Rain-fed of Sudan. *Advances in life Sciences, 1*(2), pp. 45-48.

El Naim, A M., Khaliefa, E. H., Ibrahim, K A, Ismaeil, F. M, Zaied, M M B. (2012). Growth and yield of roselle (*Hibiscus sabdariffa* L) as influenced by plant population in Arid Tropic of Sudan under Rain-fed. *International Journal of Agriculture and Forestry, 2*(3), pp. 88-91.

Hameed Ansari, A., S.M. Qayym, and M. Usman Usmani Khail. (1993). Impact of row spacing and NPK fertilizer levels on the growth, seed yield and oil content in pea nut. *Oil crops Newsletter, 10*, pp. 50-53.

Gomez, K.A., Gomez, A. A. (1984). Randomized complete block design analysis. In: *Statistical Procedures for the Agriculture Research.* John Willy and Sons, New York.

IITA (1989). The Cowpea, Biotechnology and natural pest control. *IITA Research Briefs, 9*, pp. 5-6.

Jambunathan R, Raju SM, Barde SP. (1985). Analysis of groundnut content by nuclear magnetic resonance spectrometry. *J. Sci. Food Agric. 36,* pp. 162-166.

Intodia, S.K., S.C. Mahnot, and M.P. Sahu. (1998). Effect of organic manures and phosphorus on growth and yield of groundnut (Arachis hypogaea L.). *Crop Res, 5*(1), pp. 22-26.

Ishag, H.M. (1980). *Groundnut production and research problems in the Sudan*. International workshop on groundnuts, Patancheru, India, 1980, pp. 282-84. ICRISAT.

Ishag, H.M. (1986). *Groundnut production and research problems in the Sudan.* Research on Grain Legumes in Eastern and Central Africa, Addis Ababa, Ethiopia, pp. 65-69. ICRISAT.

Jain, R.C., D.P. Nema, R. Khandhe and R. Thakur. (1990). Effect of phosphorus and potassium on yield, nutrient uptake, protein and oil content of grollldnut. *Indian J. Agric. Sci., 60,* pp. 559-561.

Mahmoud M.A., Osman A.K., Nalyongo P.W., Wakjira A. and David C. (1992). Groundnuts in Eastern Africa 1981-1990. *In: Nigam S.N. (ed.), Groundnut—A global perspective.* International Crop Research Institute for Semi-Arid Tropics, Patancheru, India, pp. 89-95.

Osman, A.K. (2003). Groundnut Production in Traditional Rain fed Sector. Book-ARC Publication.

Tai, Y.P. and Young, G.P. (1974). Variations in protein percentage in different portions of peanut cotyledons. *Crop Science, 14*, pp. 222-229.

Abdelrahman ousman and Jens B. Aune. (2011). Effect of seed priming and micro-dosing of fertilizer on groundnut, sesame and cowpea in Western Sudan. *Experimental Agriculture, 47*(3), pp. 431-443.

Kandil, A. A., A. K. A. El-Haleem, M. A. Khalafallah, S. F. El-Habbasha, N. S. Abu-Hagaza, and T. G. Behairy. (2007). Effect of nitrogen levels and some bio-fertilizers on dry matter, yield and yield attributes of groundnut. *Bulletin of the National Research Centre (Cairo), 32*(3), pp. 341-359

Kachot, N.A., Malavia, D.D., Solanki, R.M. and Sagarka, B.K. (2001). Integrated nutrient management in rainy season groundnut (Archis hypogaea L.). *Indian J. Agron., 50*, pp. 152-155.

Vijaya Kumar, P., Ramakrishna, Y.S., Krishna Murty, K., Ashok Kumar, B. and Shekh, A.M. (1997). Identifying the climatic constraints for optimum production of groundnut and delineating the areas with highest production potential on climatic basis. *In: Proc. of the Symposium on Tropical Crop Research and Development India-International, Trissur, India*.

Saxena, K.K., Arum Srivastava and Singh, R.B. (2003). Growth and yield of groundnut (Archis hypogaea L.) on influenced by nitrogen and potassium. *Farm Sci. J., 12,* pp. 57-58.

Patra, A.K. (1995). *Effect of planting variables and water management practices on seed production of groundnut varieties.* Ph.D. (Ag.). Thesis submitted to Bidhan Chandra Krishi Viswavidyalaya. Mohanpur, Nadia, West Bengal, *3*(38), pp. 218-223.

Nasr-Alla, A.E.; F.A.A. Osman, and K.G. Soliman (1998). Effect of increased phosphorus, potassium or sulfur application in their different combinations on yield, yield components and chemical composition of peanut in a newly reclaimed sand soil. *Zigzag J. Agric. Res, 25*(3), pp. 557-579.

Purushotham, S. and M.M. Hosmani. (1994). Response of groundnut to different levels of fertilizer application. *Karnataka J. of Agricl. Sci, 7*(2), p. 223. (C.F. CAB Abstr. 1996/97, no. 176 of 490).

Barik, A., P.K. Jana, G. Sounda, and A.K. Mukherjee. (1994). Influence of Nitrogen, phosphorus and potassium fertilization on growth, yield and oil content of kharif groundnut. *Indian Agric, 38*(2), pp. 105-111.

Angadi, V.V.; S.V. Patil, and M.N. Sheelavntar. (1989). Response of bunch groundnut to levels of NPK and time of N application in black soil under irrigation. *Farming Sys. 4*(3-4), pp. 73-76 (C.F. Field Crop Abstr. 43, no. 5064, 1990).

El-Far, I.A., and B.R. Ramadan. (2000). *Response of yield, yield components and seed quality of groundnut (Arachis hypogaea L.) to plant density and PK fertilization in sandy calcareous soil.* Proc. 9th Conf. Agron., Minufiya Univ., Egypt. 1-2 Sept, pp. 453-466.

Reddy S., K., V.M.M. Srirama Murthy, and M.V. Shantaram. (1992). Nitrogen, phosphrous and sulphur nutrition of groundnut (Arachis hypogaea L.) grown in alfisols. *J. Oilseeds Res,* 9(2), pp. 189-195.

Abdalla, E.A. (1999). National rain fed trial. *Annual report (1998\99), Groundnut Research Program, Agricultural Research Corporation*. *Elobeid Research Station*.

Yakadri, M. M.M. Husain, and V. Satyanarayana. (1992). Response of rainfed groundnut (Arachis hypogaea L.) to potassium with varying levels of nitrogen and phosphorus. *Indian J. Agron, 37*(1), pp. 202-203.