DEDICATION

To soul of my father "Ebraheem" ······(ALLAH mercy him)

To my mother "Laila"······· with love

To my brother and my sisters ······

To my wife " Haifaa " and daughter "Nwafil" ······

To my son Ahmed…..

ACKNOWLEDGEMENTS

Praise and thanks to ALLAH, who gave me health and patience to complete this study successfully. I'm deeply thankful to Dr. Ahmed Ali Mohammed Osman, my supervisor and Dr. Makeen Abdalla Makeen my co supervisor for him guidance, valuable suggestions and unlimited help. Deep thanks to Mr. Hatim A. ElKhidir, Mr. Omer Abdella Bakheet, Dr. Mohammed Almontsir, Mr. Tarig El tiyb, Dr Elgailani A. Abdalla, Dr Hilmmi Salih, Miss Nashwa Ebrahim, Mr Hashim Elbeshary, El arbab Jamal the leader of Faris village, Dr hatim Ebrahim and Ahmed Ali for their kind treatment and continuous encouragement.

I'm deeply grateful to ARC, Central Library members, special thanks to Hashim and Sanaa. Special thanks are due to my mother, to Abdelazeem Adlan, Abdelhaleem Hamid, Ahmed Fadl Elseed and Salah Hamdan for their great assistant. Finally, special thanks should go to my beloved wife Haifaa and my daughter Nwafil, son Ahmed who gave me comfortable environment to accomplish my work.

ABSTRACT

This experiment was conducted under rain fed condition for two season(2011 and 2012) at two location in North Kordofan, Elobeid Research Station farm and Faris village, to study effect of NPK micro dose of six groundnut genotypes (Sodiri, Gubiesh, ICGV89171, ICGV93255, ICGV86744 and ICGV92121) with two NPK micro-dose levels control and 0.6 gm per hole. The field experiment was factorial laid out in Randomized Complete Block Design with four replications. 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 highest pod yield of 526, 498 and 478 kg/ ha were recorded by ICGV86744 without NPK treatment, ICGV86744 with NPK treatment and Sodiri with NPK treatment respectively. The lowest yield of 272.4 kg/ ha was recorded by Sodiri without NPK micro dose. ICGV86744 cultivar without NPK treatment recorded the best hay yield 787 kg/ ha. Sodiri recorded best value cost ratio for pod and hay yield compared with all genotypes under study. Increase in amount of rain fall has positive effect on hay yield and pod yield, increase in both yield 12% with NPK application. 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. Some crop growth parameters were taken such as dry matter accumulation and distribution, leaf area, crop growth rate (CGR), specific leaf area (SLA) and net assimilation rate (NAR) were collected at each 30 days interval between 30 and 90 days after planting. The dry matter accumulation at the all stages of the season was high significant, a cross most of the development stages dry matter (%) distribution was not significant among genotypes. The Leaf area was

significant at 60 and 90 days after planting, NPK treatment increase the leaf area 20%. The results of the combined analysis showed that there were no significant(p =0.05) differences among genotypes for the measured growth traits throughout the season. significant differences were observed among genotypes and treatments for CGR at 30 and 60 DAP and SLA at 90 DAP. No significant differences on NAR between treatments. The high significant differences were observed between maximum temperatures and LA, TDM and SLA and negative significant correlation between maximum, minimum temperature and CGR, LA, pods and hay yield. In all treatments, with NPK micro doses application and control the correlation was same, high significant correlation was observed between LA and TDM, CGR, LA and SLA. The significant differences were found between TDM and CGR and LA, CGR and LA, LA and SLA and between pod yield and hay yield but the correlation between pod and hay yield increased with NPK micro doses application. The best Environment mean and Environmental index of shelling%, hay yield and pod yield recoded at Faris in 2012. Soderi recorded best estimated pod yield 322.4 kg/ha.

ملخص الدراسة

أجريت هذه الدراسة لمعرفة أثر استخدام السماد المركب على نمو وإنتاجية ستة طرز من الفول السوداني (ICGV89171-ICGV86744-ICGV93255-1CGV92121- سودري- غبيش) تحت ظروف المطر في ولاية شمال كردفان في موقعين هي مزرعة محطة بحوث الأبيض الزراعية وقرية فارس للموسميين متتاليين (2011 و2012) وذلك باستخدام مستويين من السماد المركب هي المشاهدة و 0.6 جرام للحفرة وقد تم تصميم تجربة عاملية بالقطاعات العشوائية الكاملة مع أربع مكررات . وقد أخذت قراءات الإنتاجية ومكوناتها، نسبة الزيت والبروتين نتائج التحليل المركب والتفاعل فيما بينهما تم تحليلها علي مستوي معنوية 5% وقد لوحظ الفرو قات المعنوية في إنتاجية القرون والتبن ، عدد القرون في النبات الواحد ، وزن المائة حبة والنضج بينما لم توجد أي فروقات معنوية في نسبة التقشير ودليل الحصاد. أعلي إنتاجية للقرون كانت 526 ، 498 و 478 كيلوجرام / هكتار سجلت بالطرز ICGV86744 بدون استخدام سماد ، ICGV86744 بالسماد المركب وسودري بالسماد المركب علي التوالي. وكانت أقل إنتاجية 272.6 كيلوجرام/ هكتار سجلت بواسطة الطرز سودري بدون إستخدام سماد مركب. كما أن الطرز ICGV86744 بدون استخدام سماد مركب أعطت أعلي إنتاجية للتبن 787 كيلوجرام/ هكتار. كما أن الصنف سودري سجلت أعلي قيمة في نسبة قيمة التكلفة. إرتفاع في معدل كمية الأمطار أدت لزيادة الإنتاجية في القرون والتبن بنسبة 20% مع استخدام السماد المركب. أعلي نسبة زيت سجلت بواسطة الصنف سودري باستخدام السماد المركب والبروتين صنف غبيش باستخدام السماد المركب. بعض قياسات تحليل النمو قد تم أخذها وهي المادة الجافة المتراكمة، ونسب توزيعها والمساحة الورقية، المعدل النسبي لنمو المحصول ، المساحة النوعية للورقة و صافي معدل التمثيل وقد أخذت قرأءاتها كل 30 يوم حتي 90 يوم عند الحصاد. استخدام السماد المركب ذادت المساحة الورقية بنسبة 20% وقد لوحظت فروقات معنوية بين المعاملات في المعدل النسبي لنمو المحصول بعد 30 و 60 يوم بعد الزراعة والمساحة النوعية للورقة عند 90 يوم بعد الزراعة. لم تسجل أي فروقات معنوية بالنسبة لصافي معدل التمثيل في أي مرحلة من مراحل النمو. كما وجدت فروقات معنوية عالية في العلاقة مع ما بين درجة الحرارة العليا مع المساحة الورقية والمادة الجافة المتراكمة والمساحة النوعية للورقة وأيضا وجود فروقات معنوية في العلاقة السالبة بين درجة الحرارة العليا والدنيا مع المساحة الورقية والنمو النسبي للمحصول وإنتاجية القرون والتبن في كل المعاملات. لم يكن لاستخدام السماد اثر في العلاقة مابين قياسات تحليل النمو و الانتاجية لكنها ذادت في العلاقة الموجبة بين إنتاجية التبن والقرون. أفضل ثبات بيئي ودليل بيئي لنسبة التقشير وإنتاجية القرون وإنتاجية التبن كانت في موقع فارس في موسم 2012 وسجلت صنف غبيش أفضل أفضل ثبات بيئي في انتاجية القرون 322.4 كيلوجرام/هكتار .

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CHAPTER ONE

INTRODUCTION

Groundnuts, or peanut (*Arashis hypogaea L.),* is a very 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 the Sudan, groundnut is one of the main cash crops; it plays an important role in the economy of the Sudan (MANR, 1985). It is produced by two production systems (Khidir, 1997). In the rain fed sector, the crop is grown in small holdings on sandy soils of low fertility, mostly under low and erratic rainfall, where the early maturing Spanish types (Gibiesh and Sodari) used to dominate the area. In the irrigated sector, groundnut is produced on heavy black cracking clay of central Sudan, where only late-maturing Virginia types (Ashford, MH383, Medani, and Kiriz) are grown. The main areas of production in the rain fed sector include South Darfur, South Kordofan, North Kordofan and Southern region (Equatoria), while the main areas of production in the irrigated sector include Gezira scheme, Rahad scheme, New Halfa scheme, Suki scheme, Blue and white Nile schemes. Under irrigated conditions, the average yield ranges between 1.5 and 2.5 tons/ha whereas the yield under rain fed conditions ranges between 0.2 and 0.8 tons/ha (Maragan, 1996), this regions is characterized by seasonal variation in rainfall and low soil fertility. The maintenance of soil fertility is becoming one of the most important interventions required to increase crop productivity in the dry areas. Application of small amounts of mineral fertilizer in the planting hole is a more efficient way to apply mineral fertilizer compared to broadcasting. This method increases both yield and the efficiency of fertilizer application The present study is to evaluate the performance of six groundnut cultivars under rain fed condition and determine their response to micro dose of NPK fertilization of some growth characters, yields and its components.

The objective are:

1- To study effect of NPK micro dosing fertilizer on yield of six groundnut genotypes.

2- To identify the effect of rainfall amount, distribution on yield of genotypes under study.

3- To detect the relationship between NPK micro dose and some physiological traits among genotypes under rain fed condition.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and distribution of groundnuts

Groundnut (*Arachis hypogaea* L.) is a cultivated annual of South American origin, domesticated in the broad area between Brazil, Argentina, Paraguay, Peru and Bolivia (Tweneboah, 2000). Unknown outside the New World in pre-Columbus times, groundnut was first taken to the West Coast of Africa by the Portuguese in the 16^{th} century, while the Spanish took it to the Philippines from Peru. According to Purseglove (1998), groundnut was taken across the pacific to the Philippines by the Spaniards before spreading to Asia. Before the arrival of the first Europeans in South America, groundnut was already cultivated by the Incas in Peru and from there it spread to Mexico and the West Indies before the Portuguese imported it, especially the prostrate or so-called running type. The Brazil coast was the point of departure for the Portuguese in the 16th century who transferred the crop to West Africa, and then on to East Africa (Waele and Swanevelder, 2001). They stated that its introduction into West Africa and for that matter Ghana, is gradually replacing traditional bambara groundnuts. Tweneboah (2000) reported that out of 6 million tonnes of groundnuts produced in Africa about 80% comes from the savanna zone to the south of the Sahara and only 5% from the analogous zone in the Southern Hemisphere. He stated Nigeria, Senegal, Niger and the Sudan as the four largest producers in this zone. India is by far the largest world producer, others include China, U.S.A, The Gambia, Mali and Malaysia. All other species of the genus *Arachis* are wild and occur only in South America where they are used as forage (Waele and Swanevelder, 2001). It has also been reported that most of the produce is consumed locally.

2.2 Some uses of groundnuts

According to Kochhar (1986), green haulm of groundnut make excellent fodder and the lower grade oil from the feed also used in the manufacture of soap, lubricant and illuminants.Groundnut also called peanut, is used as food boiled and salted to improve flavour and taste,used as butter, eaten alone and in sandwiches or mixed into candies, cookies, pies and other bakery products (World Book of Encyclopedia, 1990). In Africa, they are eaten fresh, boiled or grilled and also in the preparation of soup (Waele and Swanevelder, 2001). The paste obtained after the oil has been extracted is also moulded into different shapes and fried as “Krukli”. It is used to make a synthetic textile fibre, ‘ardil’ from groundnut protein as the fibers have wool-like texture (Kochhar, 1986). Oils of groundnuts are used as ingredient in face powders, shaving creams, shampoos and paints. They are also used in making nitroglycerin (an explosive). The residue after oil extraction is a high-protein livestock feed. Groundnuts can also be used as cake, flour, peanut protein, and peanut milk for, human consumption. Medicinally, the oil of groundnut is used as a laxative and emollient (Abbiw, 1990).

2.3 Soil requirements:

Groundnuts usually grow well in light sandy to sandy-loam, well-drained, aerated soil but heavy soils or soils with a tendency to form crust are unsuitable because they hamper the penetration of the pegs during flowering and impact negatively on harvesting (Waele and Swanevelder, 2001). Hack (1970) observed that heavy clay soils make harvesting difficult, reduce yield through fracture and pod may be strained by adhering clay. Interestingly, groundnuts will grow in heavier soils according to Tweneboah (2000) if there is no water-logging and if the surface soil is loose enough to allow penetration of the ovary. Farmers have general preference for well drained, light sandy loams because of ease of cultivation and harvest.

2.4 Concept of Micro dosing

Integrated soil fertility management clearly places emphasis on the combined use of mineral fertilizers and organic inputs. A problem however is that chemical fertilizers are commonly sold in bags of 50 kg, so that purchase of these bags is limited as many smallholder farmers can simply not afford it. However, they are able to buy a 5 or 10 kg bag. Given this observation, scientists at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) developed a precision-farming technique called “micro dosing”. Micro dosing involves the application of small and affordable quantities of fertilizer (1-4 g) together with the seed at sowing or as top dressing three to four weeks after 29 emergence. Generally, the micro dose is applied together with the seeds in the planting hole by using an empty soft drink or beer bottle cap. As the fertilizer is added directly near the seed, this method enhances the fertilizer use efficiency as fewer losses of fertilizer will occur. Simultaneously the rates of fertilizer needed to optimize crop yields are reduced and as such micro dosing allows to use much lower rates in a more efficient way. As a result, farmers are triggered to invest in micro dosing if it proves to increase crop yields sufficiently (Bationo and Buerkert, 2001; Tabo et al., 2006; Sawadogo-Kaboré et al., 2008; Tabo et al., 2008; ICRISAT, 2009; Lima et al., 2010; Twomlow et al., 2010; Bagayoko et al., 2011; Buerkert and Schlecht, 2013; Winterbottom et al., 2013; De Neve, 2014). A project funded by USAID and conducted in three countries of West Africa (Burkina Faso, Mali and Niger) between June 2002 and December 2004, revealed that when farmers used the fertilizer microdosing method, yields of sorghum and millet increased by 44 to 120 percent while farmer incomes increased by 52 to 134 percent in all three participating countries (Tabo et al., 2006). Some authors however question whether these results could be replicated across different soil types, agro-ecological zones and climates (Blessing, 2014). In 2012, an estimated 360 000 farmers were already applying the technology across sub-Saharan West Africa (Buerkert and Schlecht, 2013). Although this technique is very promising, farmers do report that micro dosing requires a lot of time and labour and that it is difficult to ensure that each plant gets the right dose of fertilizer (Tabo et al., 2006; Sawadogo-Kaboré et al., 2008; Tabo et al., 2008; ICRISAT, 2009; Twomlow et al., 2010; Bagayoko et al., 2011; Buerkert and Schlecht, 2013; Winterbottom et al., 2013). Fertilizer micro-dosing technology is point application of relatively small quantities of fertilizer (2–6 g $hill^{-1}$) in cereal production. In micro-dosing, fertilizer may be placed next to the plant 2 to 3 weeks after planting (Tabo *et al*., 2008), or applied with the seed at sowing time or as top dressing 3 to 4 weeks after emergence (ICRISAT, 2009). Micro-dosing decreases substantially the recommended amount of fertilizer that smallholder farmers need to apply per hectare i.e., from 200 to 20 kg ha^{-1} in the case of di-ammonium phosphate (Hayashi *et al*., 2008). Twomlow *et al.* (2010) reported significant increases in cereal grain yield with 17 kg N ha^{-1} (approximately 25 % of recommended levels) compared to recommended rates of 55 kg ha^{-1}. However, Institutde l"Environnement et de Recherches Agricoles (INERA) has developed a method of micro-dosing which is based on application of only 62 kg of fertilizer per hectare, a reduction of one-third, the recommended rate. The technique requires only about one-tenth of the amount typically used on wheat, and one-twentieth of the amount used on corn in the USA (INERA, 2010). The techniques of applying fertilizer vary depending on soil and climatic conditions. In southern Africa, farmers use fertilizer measured out in an empty soft drink or beer bottle cap, while in western Africa, the farmers measure fertilizer with a three- finger pinch (ICRISAT, 2009). A three-finger pinch is equivalent to 6 gram doses of fertilizer which is about a full soft drink bottle cap. With ammonium nitrate fertilizer for instance, a beer bottle cap is equal to 4.5 g which is equivalent to 17 kg N ha^{-1} (Twomlow *et al.*, 2010). Farmers in the Sahel use a soda bottle cap to allocate fertilizer, hence fertilizer micro-dosing is popularly known as the Coca-Cola technique (Tabo *et al.*, 2006). Applying fertilizer in micro-dose permits more precise and better timed fertilizer placement and hence appropriate management of fertilizer (Sanginga and Woomer, 2009). This technology may be strategically combined with other practices such as seed priming, water harvesting, zai planting holes, addition of livestock manure or crop residue and compost prepared from household and garden wastes.

2.5 Effect of NPK micro dosing on yield of crops

Tabo *et al.* (2007) observed that sorghum grain yields from micro-dosed treatments were significantly higher than the control plots (1069 kg ha^{-1} verses 728 kg ha^{-1}), while millet grain yields increased from 687 kg ha^{-1} under no-fertilizer treatment to 1212 kg ha^{-1} with fertilizer micro-dosing. In Ghana, maize yield was about 250 kg ha^{-1} without fertilizer as against 1100 kg ha^{-1} with fertilizer micro-dosing (Sawadogo-Kaboré *et al.*, 2008). Some have questioned whether these results could be replicated across different soil types, agro-ecological zones and climates. Tabo *et al*. (2008) confirmed that fertilizer micro-dosing has the potential to greatly increase yields across a range of agro-ecological zones and rainfall situations in West Africa, from the drier Sahelian zone to the wet Sudano-Guinean environment. In Zimbabwe, wide scale testing of the micro-dosing (17kg N ha^{-1}) consistently showed increased grain yields by 30 to 50 % across a broad spectrum of soil, farmer management and seasonal climatic conditions (Twomlow *et al*., 2010). Also, the findings of Hayashi *et al*. (2008) showed that fertilizer micro-dosing improved the harvest index of millet crop. Ali Ibrahim, *et. al* (2016) they are studied effect of Fertilizer micro-dosing on crop yield in the Sahelian with low-input cropping system, This study was designed in the 2013 and 2014 cropping seasons to establish nutrient balances under fertilizer micro-dosing technology and their implications on soil nutrient stocks. Two fertilizer micro-dosing treatments [2 g $hill^{-1}$ of diammonium phosphate (DAP) and 6 g $hill^{-1}$ of compound fertilizer Nitrogen-Phosphorus-Potassium (NPK) (15-15-15)] and three rates of manure (100 g $hill^{-1}$, 200 g $hill^{-1}$ and 300 g $hill^{-1}$) and the relevant control treatments were arranged in a factorial experiment organized in a randomized complete block design with three replications. On average, millet (Pennisetum glaucum (L.) R.Br.) grain yield increased by 39 and 72% for the plots that received the fertilizer micro-dosing of 6 g NPK $hill^{-1}$ and 2 g DAP $hill^{-1}$, respectively, in comparison with the unfertilized control plots. The average partial nutrients balances for the two cropping seasons were −37 kg N $ha^{-1}yr^{-1}$, −1 kg P $ha^{-1}yr^{-1}$ and −34 kg K $ha^{-1}yr^{-1}$ in plots that received the application of 2 g DAP $hill^{-1}$, and −31 kg N $ha^{-1}yr^{-1}$, −1 kg P $ha^{-1}yr^{-1}$ and −27 kg K $ha^{-1}yr^{-1}$ for 6 g NPK $hill^{-1}$. The transfer of straw yields accounted for 66% N, 55% P and 89% K for removal. The average full nutrient balances for the two cropping seasons in fertilizer micro-dosing treatments were −47.8 kg N ha^{-1} yr^{-1}, −6.8 kg P ha^{-1} yr^{-1} and −21.3 kg K ha^{-1} yr^{-1} which represent 7.8, 24.1 and 9.4% of N, P and K stocks, respectively. The nutrient stock to balance ratio (NSB) for N decreased from 13 to 11 and from 15 to 12 for the plots that received the application of 2 g DAP $hill^{-1}$ and 6 g NPK $hill^{-1}$, respectively. The average NSB for P did not exceed 5 for the same plots. It was concluded that fertilizer micro-dosing increases the risk of soil nutrient depletion in the Sahelian low-input cropping system. These results have important implications for developing an agro-ecological approach to addressing sustainable food production in the Sahelian smallholder cropping system.

2.6 NPK Micro dosing studies in Sudan

Abdelrahman *et. al* (2011) they are studied the effect of seed priming and micro-dosing in groundnut, cowpea and sesame was studied for three years in on-farm and on station experiments under rain fed agriculture in North Kordofan, Sudan. The on-station trials showed that seed priming increased groundnut pod and hay yields by 18% and 20% respectively. Micro-dosing of 0.3, 0.6 and 0.9 g fertilizer per pocket increased groundnut pod yield across the three years by 36.7, 67.6 and 50.8% respectively compared to the control. The highest yield increases were consistently obtained when micro-dosing was combined with seed priming. A combination of seed priming and micro-dosing of 0.6 g increased groundnut yield by 106%. Priming alone did not significantly affect sesame seed or hay yield, but micro-dosing of 0.6 g per pocket increased the grain yield by 38% over the control. Cowpea grain yield in the on-station experiments was not significantly affected by seed priming or micro-dosing. However, both seed priming and micro-dosing increased cowpea hay yield. In the on-farm trials, seed priming increased groundnut and cowpea yields by 18.2 and 25.5% respectively, and seed priming combined with 0.3 g fertilizer increased their yields by 42.2 and 54.5% respectively compared to the control. For sesame the yield increase after 0.3 g fertilizer per pocket was 46.3%. The economic analyses of the on-station experiments showed that the highest gross margin was obtained when combining seed priming with 0.6 g micro-dosing for all the crops. These results show that the combination of micro-dosing and seed priming has the potential to increase productivity and improve net return in the crops tested. Abdalla et. al (2015) they are studied the response of sorghum, groundnut, sesame, and cowpea to seed priming and fertilizer micro-dosing in South Kordofan state, the experiments for each crop consisted of two priming levels (primed seeds vs. non-primed) and four micro-doses of NPK mineral fertilizer (0, 0.3, 0.6 and 0.9 g per planting pocket or hole). On-farm trials in 15 fields consisted of control, seed priming, and seed priming + micro fertilizer (0.3 g/planting hole). Data collected included plant vigor, stand count, plant height, grain and straw yield, seed weight, and other relevant agronomic traits. This study shows that it is possible to increase productivity of sorghum, sesame, groundnut, and cowpea in the semi-arid cracking clay of South Kordofan State at a low cost and with a moderate risk for farmers through seed priming and micro-dosing of fertilizers. Seed priming combined with micro-dosing NPK mineral fertilizer of 0.9 g was the best treatment for plant establishment, seedling vigor, grain yield, and hay yield in sorghum and groundnut, whereas the combination of seed priming and 0.3 g micro-doing of fertilizer was the best in sesame. Seed priming and micro-dosing of fertilizer of 0.6 g was the best combination for cowpea. On-farm trial results indicated that priming alone and priming combined with fertilizer application significantly increased the yields of sorghum, groundnut, and cowpea over the control (P = 0.01). Of the crops tested, groundnut responded most favorably to micro-dosing and seed priming, with a value to cost ratio (VCR) of 26.6, while the highest VCR for sorghum, sesame, and cowpea was 12.5, 8.0 and 4.4, respectively. For the best productivity and profitability, we recommend using seed priming in combination with the micro-dosing of 0.9 g/hole of 15:15:15 NPK fertilizer for sorghum and groundnut, of 0.3 g/hole for sesame, and of 0.6 g/hole for cowpea grown in the semiarid South Kordofan State of Sudan.

2.7 The fertilizer of groundnut:

The crop has a good ability for growing in lightly soil, and thrives in improving the characteristics of the newly reclaimed sandy soils which commonly suffer from some constraints such as poor physical properties and nutrients deficiency. In Egypt, during the last two decades, land reclamation is a must. Several newly reclaimed areas were performed at different governorates, including El-Fayoum, which has about 15% of its acreage as newly reclaimed sandy soils adjacent to the desert. These areas should be cultivated with appropriate crops enable to overcome its poor features and improve its productivity. In this regard, peanut is a preferable choice. So, many research attempts were carried out to manage the peanut crop and to raise its yield quantity and quality in such soil types under different agricultural practices including fertilization with the main macronutrients N, P and/or K separately or in combinations. Phosphorus (P) and potassium (K) fertilization had intensive work compared to those conducted on nitrogen (N). This might be attributed to the idea that adequate supplement of P is important for increasing nodule formation and increased N fixed by legume plants (Robson, 1983). Moreover, K has a beneficial effect on N fixation and transformation of photosynthesis from the leaves to the root nodules (Haghaparast-Tanha, 1975). So, relatively little information are available on N effect on peanut crop. Jakbro (1984) as well as El-Seesy and Ashoub (1994) suggested that N application enhanced growth and yield characters of peanut. Abdel-Halem *et al.* (1988) reported that 60 kg N/faddan was adequate dose for producing high yield in sandy soil. Phosphorus fertilization was investigated by several workers and recommended varied doses of P2O5 kg/ha for raising yield and its attributes, i.e. 25 kg (Bhatol *et al.*, 1994); 33 kg (Kumar and Ray Chudhuri, 1997); 40kg (Dwivedi and Gautam, 1992); 50 kg (Patel *et al.*, 1995); 60 kg (Yakadri *et al.*,1992) and about 114 kg (El-Far and Ramadan, 2000). Also, different potassium fertilization doses (expressed as kg K2O/ha) adequate for best growth and yield were detected by various authors, i.e. 30 (Ghatak *et al* 1997); 50 (Patra *et al.*, 1995), 60 (Timmegowdd, 1995), (Gabr, 1998) and (Abdel Halem *et al.*, 1988). On the other hand, Nour El-Din *et al.*, (1986) reported that P as well as K had no effects on growth and yield of peanut grown in soil containing high nutrient contents. Concerning fertilization with combination of these nutrient, proper different levels of N and P (expressed as kg/ha of N and P2O5, respectively) were detected by (Lal and Saran, 1988) 20 & 40; (Agasimani and Hosmani, 1989) 50&100; (Patil, 1992) 40&60 and (Patel *et al.*, 1994) 25&50. Nasr-Alla *et al.* (1998) reported that increasing the rate of PK individually or in combination increased the crop growth and yield characters. However, Chinaware *et al.*, (1995) found insignificant effect of NPK on peanut yield. 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 were; 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.

2.8 Nitrogen management in groundnut

Nitrogen in general is the major structural constituent of the plant cell. It plays an important role in plant metabolism by virtue of being an essential constituent of metabolically active components like amino acids, protein, nucleic acid, flavins, purines and pyrimidines, nucleotides, enzymes and alkaloids. The biological role of N is evidenced through the chlorophyll in harvesting solar energy, phosphorylated compounds in energy transformation, nucleic acid in the transfer of genetic information and regulation of the cellular metabolism and biological catalysts (Puntankar and Bathkal 1988). Growth and development of crops depend largely on the development of root system. Nitrogen is the key plant nutrient that stimulates root and shoot growth (Jana *et al.*, 1990). Nitrogen is closely linked to control the vegetative growth of plant and hence determines the fate of reproductive cycle (Wojnowska *et al.*, 1995). Srinivas *et al*. (2005) stated that groundnut being a leguminous crop depended on two major sources of nitrogen for their growth *viz.*, atmospheric nitrogen and mineral nitrogen benefit from the appropriate complementary operation of both biological nitrogen fixations by the species and by nitrate reduction. In general, the contribution of nitrogen in the legume would be 25 Kg ha-1. Groundnut showed a significant increase in plant height with increasing levels of N from 0 to 40 kg ha- 1 in soils with low N status (Jakhro, 1984 and Barik *et al.*, 1994). Sukanya *et al.* (1995) observed that increasing level of nitrogen increased the nodule number, nodule mass, total dry mass, total nitrogen content, pod yield and harvest index in groundnut. Barik *et al.* (1998) reported that dry matter production, LAI and plant height were increased significantly with the enhanced rate of nitrogen supply at various stages of growth up to harvest and the highest value was observed with 40 kg ha-1. However, the results of the research experiment conducted by Edna Antony *et al.* (2000) revealed that leaf area duration, leaf area index and leaf net assimilation rate increased with an increase in nitrogen dose in all genotypes studied and concluded that 25 kg N ha-1 was necessary for optimal yield. Yield of groundnut tended to decrease with higher dose of N beyond 25 kg ha-1. 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. Cox *et al.* (1992) opined that application of nitrogen in the form of urea in two equal splits at the time of sowing and at 30 DAS significantly increased the dry matter with each increment levels. Studies on the response of three levels of nitrogen *viz.*, 0, 15 and 30 kg ha-1 to groundnut during summer season was made and the results revealed that application of N at higher dose did not significantly improve the dry matter accumulation and yield attributes at harvest (Chawale *et al.*, 1993). 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). Gogoi *et al.* (2000) compared the response of different levels of N *viz.*, 0, 20, 40, 60 and 80 kg ha-1 to groundnut and found that increased level of nitrogen application up to 80 kg ha-1 increased the number of branches, pegs, pods per plant and shelling percentage. However, significant increase in yield and yield attributes were noted only up to application 40 kg ha-1. Similarly, Deka *et al.* (2001) indicated that increasing the level of nitrogen up to 40 kg ha-1 increased the nutrient uptake and resulted in significantly higher kernel and haulm yields of groundnut. Chavan and Patil (1995) studied the response of four groundnut varieties to three levels of nitrogen and observed that the variety UF 70103 showed a consistent and significant response to increased levels of nitrogen up to 40 kg ha-1, while variety JL 24 showed a significant increase in yield in response to nitrogen levels up to 25 kg ha-1.Whereas SB XI was not consistent in its response pattern. Increasing nitrogen levels up to 60 kg N ha-1 significantly increased the pod yield of groundnut and it did not respond to N beyond 60 kg N ha-1 (Singh and Singh, 2001). 2.3 Phosphorus management in groundnut Phosphorus is required in small amount than N for plant growth but is equally important for crop growth (Chen *et al*., 1994). Phosphorus is one of the major limiting plant nutrients (Nandwa 1998; Rao *et al.* 2004) in the tropical and sub-tropical soils. Agasimani and Babalad (1991) reported that response to P could be obtained when the available P status in the soil was less than 35 kg P2O5 ha-1. Kulkarni *et al.* (1986) reported that phosphorus application up to 50 kg ha-1 increased the number pods per plant and dry matter production accumulation in the plant. Patel *et al.* (1990) revealed that phosphorus is the most important nutrient which affects the yield and quality of leguminous crops including groundnut. P fertilization particularly at flowering and pod formation stages were beneficial (Singh *et al.*, 1991). Groundnut responds to P application by increasing shelling percentage, oil yield and nodulation. Pushpendra Singh *et al.* (1994) reported that phosphorus application broughq2`1t about significant increase in biological yield in calcareous soils at Udaipur in Rajasthan. However, they observed significant differences at 40 and 60 kg over 20 kg P2O5 ha-1. Mudalagiriyappa *et al.* (1995) observed positive effect on pod yield due to P application @ 50 kg P2O5 ha-1 in the form of single super phosphate in different proportions in vertisols. Mehta and Ram Mohan Rao (1996) reported that application of 50 kg P2O5 ha-1 registered significantly higher number of pods per plant and 100 kernel weight. The increasing trend in pods and haulm yield was noticed up to 75 kg P2O5 ha-1. Sharma and Yadav (1997) reported that phosphorus plays a beneficial role in legume growth promoting extensive root development and thereby ensuring a good yield. Barik *et al.* (1994) observed that the plant height increased linearly by the application of P and the highest value was observed at 80 kg P2O5 ha-1. 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. Phosphorus fertilization was investigated by several workers and recommended varied doses of P2O5 kg ha-1 for increasing the yield and its attributes, *i.e.* 25 kg (Bhatol *et al.*, 1994); 33 kg ha-1 (Kumar and Ray Chudhuri, 1997); 50 kg ha-1 (Patel *et al.*, 1995); 60 kg ha-1 (Yakadri *et al.*, 1992) and about 114 kg ha-1 (El-Far and Ramadan, 2000). Rath *et al.* (2000) reported that application of

75 kg P2O5 ha-1 produced the highest pod yield (21.51q ha-1), whereas the highest oil yield was obtained with 50 kg P2O5 ha-1 due to higher shelling percentage and oil content. Bhatol *et al*. (1994) concluded that application of 25 kg P2O5 ha-1 markedly increased the pod yield over control, but a higher rate of 50 kg P2O5 ha-1, the yield was significantly decreased. Similarly Choudhary *et al.* (1991) reported that deletion of P application had significantly reduced the pod and haulm yields of groundnut.

2.9 Potassium management in groundnut

Groundnut crop responds well for potassium (K) application and addition of K increased its concentration at all stages in groundnut crop. The concentration of K was high in initial stages and declined in the later stage, indicating that groundnut absorbs K rapidly in early stages (Madkour *et al*., 1992). Potassium is also required in large amount by oil seed crop (Singh, 2004). Additional dose of 12 kg ha-1 apart from the recommended basal application of 54 kg ha-1 gave 10 per cent higher yield (CSM, 1990). Application of potassium at 100 kg ha-1 significantly increased the plant height, nodule weight, and pod number, pod and haulm yields of groundnut (Singh and Vidya Chaudhari, 1996). Kankapure *et al.* (1994) observed beneficial effect of K on growth characters including dry matter of groundnut. Jana *et al.* (1990) observed that K up to 49.8 kg ha-1 had increased the number of pods per plant, 100 seed weight, pod yield and oil yields. The response was quadratic and also influenced the K content of seeds. The pod and haulm yields of groundnut increased significantly with application of 40 kg K2O ha-1 over lower dose and further increase beyond this level did not increase the yield. Oil content in kernel increased with graded levels of K and the effect was marked to the higher at 60 kg K2O ha-1. However, increase in protein content and protein yield was only up to application of 40 kg K2O ha-1 (Deshmukh *et al.*, 1992). Application of K also resulted in higher uptake of NPK and also increased the pod and kernel yield. Quality parameters were also enhanced by the application of K which reflected in oil and protein content (Lakshmamma *et al.,* 1996). Hameed Ansari *et al.* (1993) found that application of potassium up to 45 kg ha-1 significantly improved the pod yield (3392 kg ha-1) and its contributing characters compared to lower dose of 15 and 30 kg/ ha.

2.10 NPK content and uptake by groundnut

Rao and Narayan (1990) noticed that many groundnut cultivars had higher uptake and accumulation of N and P due to application of higher doses of N and P. The difference in potassium uptake could only be due to differences in the pod and haulm yields because the crop received uniform potassium doses (Prameela Rani *et al*., 1991). Application of K, in general increased N, P and K content in all the plant parts at harvest stage. On an average 137.3, 16.6 and 63.34 kg N, P and K ha-1, respectively were removed by groundnut crop (Deshmukh *et al.,* 1992). High nitrogen levels increased nitrogen and phosphorus contents and concentration of all plant components in early growth stage only (Loubser and Human, 1993). Manoharan *et al.* (1994) reported that the uptake of N, P and K increased with increasing levels of nitrogen. Zharare (1996) demonstrated that potassium application increased the nitrogen uptake but did not affect the uptake of phosphorus and potassium. Sarmah *et al.* (1995) found that nitrogen uptake was maximum with 80 kg ha-1. An experiment conducted in sandy loam soils of Bhuvaneswar indicated that nitrogen up to 60 kg ha-1 increased the uptake of N, P and K (Mishra *et al.*, 1995). Increase in available N might be due to the direct addition of N through inorganic fertilizers to the available pool as reported by Bellakki and Badanur (1997). Combined application of N and K in equal split doses as basal and on 45 DAS coinciding with peg formation increased the uptake and availability of nutrients as well as groundnut production (Balasubramanian, 1997). Enhanced P content and uptake in groundnut leaf stem and kernel could be attributed to increased availability of P in soil due to application of organic manures (Lupwayi *et al.*, 1999). Deka *et al*. (2001) studied the effect of lime and N on nutrient uptake in groundnut and the results revealed that with each successive increase in the dose of nitrogen, nitrogen uptake increased significantly up to 40 kg ha-1, which was however at par with 60 kg ha- 1. Badole *et al.* (2003) studied the effect of organic and inorganic fertilizer on the uptake of groundnut at Parbani during summer season in the clay loam soil and found that integrated nutrient supply system (50 per cent of recommended nutrient content through organic and remaining by inorganic fertilizers) significantly improved the uptake of groundnut compared to control.

2.11 Response of Groundnut to NPK fertilizers:

Information about groundnut nutritional requirement are rather conflicting. While some researchers reported the crop to be soil exhausting, others stated that it rarely requires fertilizer N since it fixes N. Moreover, groundnut is reported to utilize fertilizer residues from preceding crops (Sinha, 1991). El Tahir (1997) showed that application of both nitrogen and phosphorous significantly increased number and weight of nodules per plant, number of branches, shoot dry weight per plant, protein content and phosphorous content. Collins *et al*., (1986) observed that addition of phosphorus and sulphur increased nodule number on the sandy soil but not on the silt loam soil. El Tahir (1997) showed that application of P did not significantly increase hay yield, number of flowers, seed oil and seed sulphur content. Chapman and Carter (1975) reported that groundnut removes relatively large amounts of certain nutrients from the soil. However, like other legumes it can fix atmospheric nitrogen and therefore nitrogen fertilization is rarely required. Chapman and Carter (1975) observed that a proper balance of phosphorus and nitrogen are essential for early maturity. However if the preceding crop before groundnut is well-fertilized, there will be no need to apply N, P or K. Application of phosphorous significantly increased plant height, kernels/plant, dry weight per plant and shelling percentage. However, effect on number of branches/plant and 100-kernal weight was not significant. Phosphorus element is an essential nutrient for crop growth and high yield with good quality. In this aspect, Nasr-Alla, *et al.*, (1998) reported that increasing the rate of PK as single or in combined application increased number of branches/plant, yield of pods/plant and yield of pods/fed of groundnut. Sinha (1970) observed that placement of super phosphate either in contact or 3-5cm below the seed was equally effective and significantly superior to broad cast application in the uptake of fertilizer phosphorus, but not in the dry matter weight or total phosphorus content of the plant. In research stations as well as in trials on farmers fields, 20-60kg P_2O_5/ha has been found remunerative for oil seeds under a conditions (Kulkarni, *et al.*, 1986). In some situations, either no or little response of groundnut to P has been observed. Mukherjee, *et al.*, (1999) observed that crops and P level had significant interaction on yield and yield components. Gobarah, *et al.*, (2006) showed that increasing rate of phosphorus fertilizer from 30 to 60 kg P_2O_5/fed significantly increased vegetative growth, yield and its components as well as seed quality i.e. protein content and NPK percentages, while oil percentage did not reach the level of significance by increasing the P rate. Ali and Mowafy, (2003) found that adding phosphorous fertilizer caused significant increase in seed yield and all its attributes. El- Habbasha, *et al.*, (2005) reported that increasing phosphorus levels increased shoot dry weight, number of pods and seeds/plant , weight of pods and seeds/plant, 100-seed weight, seed and oil yields, oil percentage, seed protein content as well as NPK contents of groundnut. Correlation of available P with pod yield and nutrient uptake indicated that sub soil fertility made an important contribution to nutrient uptake by groundnut (Patil and Patel, 1985). Viarmant and Dhalinal (1970) reported that P uptake by groundnut was mainly from the upper 40cm of the soil and was high from flowering to the peg stage. Devarajan and Kethan daraman (1982) observed that the highest pod yield of groundnut was obtained by adding 60kg P_2O_5 and 90 kg K_2O/ha. 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. Tomar, *et al.*, (1990) observed significant increase in pod yield in groundnut with application of 40 Kg P_2O_5/ha, when rainfall was well distributed. Kulkorni, *et al.*, (1986) stated that application of 50kg P_2O_5/ha increased the number and weight of nodules, N content, dry matter accumulation and pod yield of groundnut. Budhar, *et al.*, (1986) reported that response of irrigated groundnut to application of P in the range of 0-120kg P_2O_5/ha depended on soil P content. Kumar and Ras (1990) observed that P application increased pod yield from 2.53 t/ha (control) to 7.94 t/ha; but there were no statistically significant differences in yield between P application rates. Dubey, *et al.*, (1991) observed that application of P increased N, P, K, Ca and Mg content but decreased S content in seeds.

2.12 Genotypes X environmental interaction:

2.12.1 Temperature:

Temperature was identified as a dominant factor for controlling the rate of development of groundnut (Cox 1979). Every crop has its cardinal temperatures (i) base (Tb ;), (ii) optimum (To) and (iii) maximum temperatures(Tm). These are defined respectively as: (i) temperatures above which growth and development begins, (ii) temperatures at which growth and development are maximum, and (iii) temperatures above which growth and development ceases. Mohamed (1984) reported cardinal temperatures for seed germination in 14 contrasting genotypes of groundnut, which are shown in Table 3. These values showed that Tb is not varying much across genotypes (ranges from 8-11.5ºC), whereas optimum temperatures (29-36.5ºC) and maximum temperatures (41-47ºC) are varying much. Base temperature was reported to be highest during reproductive phase (3-10º0 C higher) than during vegetative phase (Angus et al. 1981). In contrast, Leong and Ongn (1983) showed Tb to be conservative for many processes and phases of groundnut cv robut 33-1. Optimum temperatures for different growth and developmental processes of the crop are presented in Table 4. Optimum temperatures for different processes ranged between 23 to 30 0 C. Optimum temperatures for germination and leaf appearance was observed to be higher than for other processes. Williams et al. (1975) reported that the optimum temperature for vegetative growth of groundnut plants were in the range of 25-30ºC while optimum temperature for reproductive growth lowers (20-25º C). The duration of the crop is very much influenced by temperature. Bell et al. (1992) reported an early bunch variety maturing in 120-130 DAS at mean temperature of 23º0 C while the same variety matures in 105 DAS when grown in coastal environment with slightly higher mean temperatures (25º0 C). Such strong effects of temperature on groundnut phenology have also been reported by others (Leong and Ong 1983; Bagnall and King 1991). Crop duration was shortest in humid tropical and sub-tropical environments, with both high and low temperatures apparently affecting crop maturity (Bell and Wright 1998). Williams et al.

(1975) reported the total growing period of the crop to be shortened from 176 days at temperature 18ºC to 151 days at 23ºC. The duration of groundnut cv Robut 33-1 from sowing to the end of seed filling increased from 95 days at 31ºC to 222 days at 19ºC. Not only the duration of crop but also the growth and yield traits were influenced by temperature. Craufurd et al. (2000) exposed 8 genotypes to either high (day/night temperature, 40/28ºC) or optimum (30/24ºC) temperature from 32 DAS to maturity and reported that rates of appearance of leaves and flowers were faster at 40/28ºC when compared to 30/24ºC. As groundnut pods are developed under the soil it is important to understand the influence of soil temperature. Prasad et al. (2000) reported that exposure to high air and or high soil temperature (38/22ºC) significantly reduced total dry matter production, Partitioning of dry matter to pods and pod yields in two cultivars. High air temperature had no significant effect on total flower production but significantly reduced the proportion of flowers setting pegs (fruit-set) and in contrast high soil temperature significantly reduced flower production, production of pegs forming pods and 100 seed weight. Furthermore, the effects of high air and soil temperatures were mostly additive. Higher temperature, promoted greater vegetative growth and higher photosynthesis in 3 genotypes of groundnut, but the reproductive growth was decreased, due to greater flower abortion and decreasing seed size (Talwar et al. 1999; Prasad et al., 2003). Similarly, temperature (expressed as degree day) and rainfall during the reproductive period positively influenced the pod yield and together they explained 86% of yield variation (AICRPAM 1997). Temperature and light intensity affected flower numbers of groundnut varieties and these changes were also well correlated with growth related changes in leaf number and pod dry weight (Bagnall and King 1991). In crop models, the optimum temperature for canopy photosynthesis was between 24-34ºC (daytime mean temperature) with linear reductions below 24ºCdown to 5º 0C and with linear reductions above 34ºC up to 45ºC (Boote et al.1986). Vijaya Kumar et al. (1997), while analyzing the variability of groundnut yield at 3 locations across varied soil and climatic conditions in relation to temperature and rainfall observed that Bangalore region despite experiencing higher rainfall than Anantapur and Anand regions, had lower average pod yield due to comparatively lower than optimum mean temperatures .

2.12.2 Rain fall and rainfall distribution

Rain fall is significant climatic factor affecting groundnut production, as 70% of the crop area under semi- arid tropic characterized by low and erratic rain fall. Low rain fall prolonged dry spells during the crop growth period were reported to be main reasons for low average yields in most of regions Asia and Africa, for example in India (Reddy et. al.2003), China (Zeyong (1992) and several parts of Africa (Camberlin and Diop, 1999). Zeyong (1992) reported that drought is most important constraint of groundnut production in China; especially in parts of northern were rain fall is less than 500mm yr-1. Naing (1980) reported that rain fall was main factor determining yield in Myanmar. Camberlin and Diop (1999) reported that after removing decadal trends, almost half of the variance groundnut production in Senegal is explained by rain fall variability specially during the early part of the rainy season (July-August). Persistent drought and insufficient rainfall represent one of the greatest constraints on groundnut crop in Senegal. Groundnut requiring average rainfall of 600-1200 mm per year under Senegal’s climatic conditions is receiving 500-700 mm of rainfall per year (Badione, 2001). Dulvenbooden et al. (2002) reported that groundnut production in Niger is significantly determined by rainfall during July to September. In India groundnut yields were reported to be vulnerable from year to year because of large inter–annual variation in rainfall (Sindagi and Reddi 1972). Bhargava et al. (1974) reported that 89% of yield variation over four regions of India could be attributed to rainfall variability in the August to December growing period. Challinor et al. (2003) analyzing 25 years of historical groundnut yields of India in relation to seasonal rainfall concluded that rainfall accounts for over 50% of variance in yield. Gadgil (2000) observed that the variation in groundnut yield of Anantapur district arises to a large extent from the variation in the total rainfall during the growing season. It was observed that seasonal rainfall up to 50 cm is required to sustain a successful groundnut crop in this region. Yield in this region can be indirectly related to El-nino events, as in 87% of El-nino years the Anantapur region received less than 50 cm of rainfall affecting the groundnut yield. At Anantapur centre of India, pod yield of groundnut showed highly significant curvilinear relationship with moisture use i.e., sum of rainfall and soil moisture (AICRPAM, 2003). Moisture use of 350-380 mm was found to be optimum for getting maximum yield and moisture use either less than or more than this amount reduced pod yield. However, Popov (1984) and Ong (1986) showed poor relationship between groundnut yield and seasonal rainfall, highlighting the higher importance of rainfall distribution to groundnut yield than the quantum of rainfall. The importance of rainfall distribution to groundnut yield is well appreciated, but experimental evidence is poorly documented (Ong, 1986). Work in a controlled environment at Nottingham University, U.K, showed yield of a crop to be four times greater than the yield of crop which used the same amount of water, but was irrigated during vegetative phase only (ODA 1984). Results from a series of experiments at ICRISAT (1984) showed that early stress or lack of rainfall/soil moisture during 29-57 days after sowing (DAS) did not influence pod yield significantly, where as pod yields were increased by 150 kg/ha/cm of water applied during seed filling stage (93-113 DAS). Pod yield of groundnut and rainfall received during pod formation to maturity were positively correlated in a rain fed crop grown at semi-arid region of Andhra Pradesh in India (Subbaiah et al., 1974). Patra et.al. (1995) studied the seasonal effect on growth and yield of peanut variety JL 24 at Kalyani, West Bengal and reported higher plant height, dry matter production, LAI, CGR, LAD, hundred kernel weight, number of kernels pod-1, pod and haulm yield during summer season compared to rainy season. However, the number of pods plant-1 was higher in rainy season than in summer season. Liang Xuangquiang et.al. (1996) assessed the performance of fifteen peanut genotypes developed at ICRISAT in rain fed upland fields during autumn and spring seasons. During both the seasons, the large seeded peanut variety ICGV 86742 gave significantly higher pod yield of 2.35 t ha-1 indicating no seasonal variation. Similar observation was also made by Patra et.al. (1996) in ICGS 44 variety, which performed well in terms of pod and oil yields during both rainy and summer seasons. Further, Tirupati 4, a Spanish bunch variety was compared with JL 24 during three kharif and three Rabi seasons, and found that pod and kernel yield of Tirupati 4 was 19 and 20 per cent more in the Kharif season, and 16 and 24 per cent more in the Rabi season, respectively than JL 24 which indicated the stability of the variety (Ramachandra Reddy et.al. 2000). Subramaniyam et.al. (2000) on identification of elite short duration rosette lines in world germplasm collection revealed that among the fifteen peanut genotypes studied during rainy and post rainy seasons, irrespective of the peanut genotypes, the higher pod yield was observed during rainy season as compared to post rainy season. Most of the crop is produced in regions with an annual rainfall of 400mm or more under low evaporative demand but there is a minimum requirement for 200mm during the growing season although this is greater in soils that do not store winter rainfall (Gibbon and Pain, 1985). A good rainfall distribution during the vegetative period of growth will encourage adequate flowering and proper development of the nuts (Tweneboah, 2000). Kochhar (1986), indicated that enough rainfall of 500 to 1000mm per year to ensure high respiratory exchanges during pod formation and vegetative period of growth. On ideal temperature for groundnut, Tweneboah (2000) reported 24-30°C, but a minimum of 12-15°C is required for germination and at least 24°C is necessary for flowering and seed setting. Groundnut is essentially a tropical plant and requires a long and warm growing season. The favorable climate for groundnut is a well-distributed rainfall of at least 500 mm during the crop-growing season, and with abundance of sunshine and relatively warm temperature. Temperature in the range of 25 to 30ºC is optimum for plant development (Weiss 2000). Once established, groundnut is drought tolerant, and to some extent it also tolerates flooding. A rainfall of 500 to 1000 mm will allow commercial production, although crop can be produced on as little as 300 to 400 mm of rainfall. Groundnut thrives best in well-drained sandy loam soils, as light soil helps in easy penetration of pegs and their development and their harvesting. The productivity of groundnut is higher in soils with pH between 6.0-6.5.

2.13 Growth characters:

2.13.1 Dry matter accumulation and distribution

Experiment conducted at Kongwa experiment Station, Tanganyika, under rain fed conditions, on red loam soil indicated that the dry matter production per plant in (bunch groundnut type) increased linearly from 0.23g per plant on 8th day to 23.74g on105th day. Nearly 45-50% of total dry matter produced in the plant was accumulated in pods and 16% in shells, 20% in stems, 11% in leaves and 1% in roots (Bunting and Anderson, 1960). Some studies revealed that the rate of growth was very rapid in the first two fortnights from flowering, and peak growth was attained during the second fortnight in bunch types. Sastry *et al.* (1980) recorded progressive increase in dry matter up to harvest. The increase, however, was very rapid up to 75 days. On an average, the weight of each plant at harvest ranged from 40-60g in bunch types. The growth rate was found to be faster in the erect varieties than in the spreading types (Surajbhan, 1973). Sashidhar *et al.* (1977) reported varietal differences in the rate of accumulation and also in the total accumulation of dry matter. Seshadri, (1962) also had referred to the varietal differences in growth in groundnut. Growth is a genotypic character, though, largely. Influenced by seasonal and other environmental conditions. Higher rate of growth during early stages and more dry matter accumulation were seen in bunch types (sequential) in comparison with other genotypes (alternate). In studies conducted by Williams *et al*, (1975), Enyi, (1977) and Duncan *et al*, (1978) the growing duration was long in all genotypes and there was a reduction in stem weight during pod filling period. However, experiments conducted at Banglore by Sastry *et al*, (1980) showed that there was considerable variation in the dry matter produced in crop growth period. Aboagye *et al*, (1994) in study conducted in two years (1990 and 1991) showed that the highest dry matter was produced by cultivars grown in season 1990 as compared to those of 1991. The crossing types, Kanto 56, Na-kateyutaka and Tachimasari, had early on-set of pod formation around 50 days after sowing (DAS) whereas pod formation was late in 334A, Valencia, Chiba 43 and Tarapoto. Nakateyutaka and Chiba 43 produced the highest biomass of 1328 and 1314 gm^{-2} respectively. With the exception of 334A, a relatively higher dry matter was accumulated in the pods of the crossing types. Tarapoto and Valencia showed greater dry matter accumulation in the stems and leaves. Generally, the Spanish and Valencia types showed greater percentage of stem dry weight. The crossed types had higher percentage of dry matter in the pods as compared to the stems; and the Virginia types had intermediate percentage dry matter values in the stems and pods.

2.13.2 Growth analysis

Enyi (1977), reported that mean NAR did not differ much among genotypes. Mean NAR of "Domoda Edible" (a spreading type) was 0.131 g/d m^2/week and of "natal common" (a bunch type) was 0.134 g/d m^2/week for the entire sampling period, but between pod initiation and final sampling it was significantly higher in "Domoda Edible" than in natal common. Significant relationship (r = 0.881) was observed between CGR and LAI during 90 to 120 days after sowing. There was also a positive relationship between mean CGR and grain yield. The change in CGR accounted for about 96% of the variation in the grain yield. Duncan *et al.* (1978) observed no significant differences in CGR of 5 genotypes of groundnut but all of these gave much higher CGR than that of soybeans. Janamatti (1979) found no differences in NAR amongst the 4 bunch groundnut genotypes during the vegetative phase (0-25 days). In all genotypes NAR decreased during flower initiation (25-40 days), pod initiation and pod development (40-70 days) stages except in 'MGS7' and 'NG268' and 'DH 3-30'. There was a decrease in NAR during the peak pod-filling period in 'C55-436' and 'MGS7'. In 'NG268' higher NAR during the peak pod-filling period was recorded, the increase in shoot weight was more in it than 'DH3-30'. Thus more metabolites were translocated to pods at the cost of shoot in 'DH3-30'. Williams *et al.* (1975) Studying the growth of groundnut at 3 altitudes in Rhodesia, showed that the CGR of 'Makulu Red' was inversely related to altitude.

CGR was the highest at the hottest site (mean daily temperature 23.3 ºC) but the maximum yield of kernels was achieved at an intermediate temperature (20.1 ºC). Maximum CGR in groundnut genotypes grown in grasslands (17.9 ºC) was 88 g/m^2/week, at Messa (20.1 ºC) 120 g/m^2/week and at Panmure (23.3 ºC) 194 g/m^2/week, (coinciding with maximum leaf area) at 16, 14 and 12 weeks, respectively after sowing. Janamatti (1979) observed a progressive decrease in the RGR in all genotypes with 'MGS7' and 'NG268', showing marginal increase. The genotypes did not differ significantly in RGR between 25 and 40 days. Higher value of RGR in 'NG268' during the peak pod-filling period was reflected by increase in shoot weight. Surilharn *et al.* (2002), observed significant differences among genotypes for SLA. Line ICGV86388 had the lowest SLA value, with an average of 150.0 $cm^{-2}g^{-1}$ over two crosses. The line IC10 was intermediate (mean of two crosses = 182.2 $cm^{-2}g^{-1}$) and the cultivar KK 60-1 had the highest SLA value (mean of two crosses= 200.55 cm^2g^{-1}). Aboagye *et al,* (1994) in a study conducted during two consecutive years (1990 and 1991) observed higher CGR during the initial growth period in the crossing types-Nakateyutaka, Tachimasari, Kanto 56, and the Virginia types-Chibahandachi and Chiba 43. In the later growth period, Nakateyutaka, Chibahandachi, Hotakuchuryu and Kintoki had substantially higher CGR. Valencia and Kanto 56 had the highest CGR, and Hakuyu 7-3 and Hotakuchuryu had the lowest CGR during the entire growth period. Banterng *et al* (2003), studied seasonal variations and growth of 14 large seeded Virginia-type and 14 small seed Spanish type breeding lines of groundnut. They found that variations among lines within each group were small. They also reported that pod growth rate was the most important yield determinant, while the crop growth rate had lesser effect and partioning coefficient and pod-filling duration had no significant effect. Enyi (1977), observed variation between two groundnut cultivars in pod number, LAI, leaf area duration, crop growth rate, number of seeds per pod and 100-seed weight due to differences in their plant density and fertilizer treatments. Positive correlations of pod yield with leaf area index and leaf area duration were also observed. Kathirvelan and Kalaiselvan (2006), studied growth characters and physiological parameters of four groundnut varieties. The results of their study indicated that the highest yielding varieties had the highest dry matter production, LAI, CGR, RGR and NAR. In contrast, Williams *et al* (1975), found a weak relationship between CGR and yield, yield and total dry matter and yield and leaf area index. He attributed this to poor and variable growth distribution between vegetative and reproductive components.

2.14 Nodulation

Nitrogen is the most limiting nutrient for crop production in agro-ecosystems (Singh *et al*., 1990; Ssali and Keya, 1980). This is because atmospheric N and fertilizer N make up the main source of nitrogen in crop production, whilst N is lost through harvested produce, decaying materials, denitrification, leaching and volatilization (Singer and Munns, 1991; Loomis and Connor, 1992). Nodulation and nitrogen fixation is only effective after three weeks and groundnut respond well to small doses of nitrogen fertilizers at the early stage of growth in some areas. The substantial nitrogen needs of groundnuts are partly satisfied by symbiotic fixation. However, numerous reports in the literature indicates positive responds to an application of N at sowing (starter nitrogen), reflecting the absence of biological nitrogen fixation at the early stages of growth (Piggott, 1960; Ssali and Keya, 1980).

2.15 Groundnut genotypes Stability

High yield is the main goal of most plant breeding programs. Although yield traits are governed by a pool of major genes, the best performance of genotypes often depends on environmental conditions, resulting in a strong genotype and environment (GE) interaction. A strategy to reduce this interaction is based on cultivar selection, considering production stability in different locations in order to discriminate cultivars adapted to favorable and unfavorable environments. Knowledge on the performance and adaptability of genotypes to particular environments is fundamental to estimate the agronomical value of cultivars and for their recommendation for specific environments (Murakami et al., 2004). Moreover, performance stability allows for the identification of stable genotypes, with a predictable performance in different environments. Zhengfeng et al. (2008) evaluated six ditions across Pakistan. groundnut cultivars under 19 ecological regions for variation and stability of pod yield and yield components in Shandeng, China and found that significant effect of environment, cultivar and interaction between environment and cultivar on pod yield variation and yield components. Mekontchou et al. (2006) evaluated six groundnut advance lines at four locations in Cameroon. Yield stability and its components were evaluated. Significant line x environment interaction was detected for all traits. Four entries exhibited stability as shown by their regression coefficient, which were close to unity. Ali et al. (200 1) reported that top yielding entries BM-28 and ICGV-86550 were stable and found desirable. Sojitra and Pethani (1998) reported the importance of nonlinear components of variance for 1000 pod weight and shelling percentage. Small pod variety J-11 was reported widely adaptable and other bold pod varieties GG-2 and Girnar of groundnut were insensitive to change in environment.

CHAPTER THREE

MATERIAL AND METHODS

3.1 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 N and longitude 30.1E). 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

Source: Elobeid Agriculture Research Station (soil lab)

3.2 Climatic conditions

The data on climatic parameters such as rainfall (mm), mean maximum and mean minimum temperature (°C) recorded at the Meteorological Observatory, Elobeid Agricultural Research Station, during the experimental years and the mean of the last 56 years (1950-2005) from new locclim computer program (FAO, data set 2005) are presented in Table 2and 3.

Table (2):Amount and rain fall distribution at El Obeid Station and Faris:

Month	Amount of rainfall(mm) El Obeid 2011		Amount of rainfall(mm) El Obeid 2012		Amount of rainfall(mm) Faris 2011		Amount of rainfall(mm) Faris 2012	
	Amount	Rainy days	Amount	Rainy days	Amount	Rainy days	Amount	Rainy days
May	34.5	2	22.5	1	0	0	0	0
June	0.00	0	56.5	8	68.5	2	18.5	1
July	62.5	5	163.0	8	186.5	7	110	3
August	140.0	9	189.0	11	179.5	6	217	5
September	58.0	7	15.0	1	51.0	1	163	4
October	31.0	5	2	1	7	1	0	0
Total	326.0	28	448.0	30	492.5	17	508.5	13

Table (3): Mean maximum and minimum temperature (°C) at study sites:

Month	Elobeid				Faris			
	maximum		minimum		maximum		minimum	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
July	36.6	32.2	23.1	23.1	35.0	34.0	20.5	20.5
August	31.8	32.0	22.5	22.5	34.5	31.5	20.0	20.2
September	34.7	34.5	22.7	22.7	31.7	35.0	18.2	20.0
October	37.2	37.6	22.7	22.9	26.7	33.0	14.3	18.0

3.3 Experimental design and layout procedure

The field experiment was factorial, laid out in Randomized Complete Block Design with six genotypes of groundnut and two levels NPK (15:15:15) micro dose treatments are 0.6 gram / planting hole and control. 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 Pornstar 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. Experiments were weeded twice, after two weeks, and four weeks from sowing. 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. The crop was harvested after 90 days in each location and in each season. During the growing period samples were taken at 30 days interval until harvest. 10 plants were selected randomly from net plot area of each treatment and tagged. Observations were recorded at 30, 60, 90 days after planting. Growth and plants were partitioned into stem leaves and fruiting parts (pods) and were dried at 85°C in hot air oven to constant weight. The oven dry weight of each part was recorded separately. The sum of dry weights of all plant parts were taken as the total dry matter production plant^{-1}.

Table (4): 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.

3.4 Yield and yield components

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

3.4.1 Number of pods per plant

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

3.4.2 Hundred seed weight (g)

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

3.4.3 Shelling percentage

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

3.4.4 Pod yield / (kg ha-1)

The pod yield (kg ha-1) was worked out from the pod yield obtained per plot.

$$\frac{\text{Weight of pods (kg/plot)}}{\text{Harvest plot area } (m^2)} \times 10000$$

3.4.5 Hay yield / (kg ha-1)

The pod yield (kg ha-1) was worked out from the pod yield obtained per plot.

$$\frac{\text{Weight of hay (kg/plot)}}{\text{Harvest hay area } (m^2)} \times 10000$$

3.4.6 Harvest index (HI)

$$HI = \frac{\text{Pod yield}}{(\text{Hay yield} + \text{pod yield})} \times 100$$

3.4.7 Value cost ratio

Value cost ratio (VCR) is the ratio between the value of the additional crop yield obtained from fertilizer use and the cost of fertilizer used. The gross rate of returns from fertilizer application to maize and cowpea crops, represented by the VCR, was calculated according to Roy *et al*. (2006). Calculation: VCR = (x - y) ÷ z

Where:

x = value of crop produced from fertilized plots

y = value of crop produced from unfertilized plots

z = cost of fertilizer

The prices according to ElObeid Auction Market 2011–2012, pods and hay prices from the local market were 5 and 1.5 SDG per kg respectively. The market price of 15-15-15 NPK fertilizer was 250 SDG per 50 kg sack (5 SDG/Kg).

3.5 Seed Quality parameters

3.5.1 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., 1970).

3.5.2 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

3.6 Crop Growth traits

Data collected and measurements made included:

3.6.1 Dry matter accumulation and distribution

At each sampling the plants were separated into leaves, roots, shoots, pods. This material was dried on oven (Imperial laboratory –oven) at about 80 c^o for 48 hours and the dry matter of each organ were weighed.

3.6.2 Leaf area plant-1(cm^2)

Leaf area was calculated using leaf area meter (Model AM 101.001). Leaves from one plant were collected and their area was measured by the leaf area meter. Then, these leaves were dried and weighed. The leaves of the sampled plants were dried and weighed. Using area: weight ratio the total leaf area calculated as follows:

$$LA\ (cm^2) = \frac{\text{Leaves weight of all the sampled plants}}{\text{Leaves weight of the one plant measured by area meter}} \times$$

Leaves area of the one plant measured by leaf area meter

These characters were measured according to formulas suggested by Vivckanadan et al, (1972). Traits measured were:

3.6. 3 Crop growth rate (CGR) :(g\day)

It is defined as rate of dry matter production per unit time. It was worked out by using the formula proposed by Watson (1952) and is expressed as g\dm-^{2}\day-1

$$(W_2 - W_1) \div (T_2 - T_1)$$

Where:

W: Plant dry weight

T: Time of sample

Where: W: plant dry weight T: time of sample

Where: LA: leaf area Subscripts 1 and 2 denote first and second sample period.

3.6.4 Specific leaf area (SLA): (cm^2\g):

$$(LA \div LW)$$

Where: LA: leaf area   W: leaf weight

3.6.5 Net assimilation rate (NAR) (g\dm^2\day):

Net assimilation rate is the rate of increase in dry weight per unit leaf area per unit time (Watson, 1952) and is expressed in g\ dm-2\day-^{1}. It was calculated by using the formula Suggested by Gregory (1926).

$$\frac{W_2 - W_1}{LA_2 - LA_1} \times \frac{\log LA_2 - \log LA_1}{T_2 - T_1}$$

L1and W_1 = Leaf area in dm² and dry weight of plant in g at time t1respectively L_2 and W_2 = Leaf area in dm^2 and dry weight of plant in g at time t_2 respectively $t_2$and t_1 = The time interval in days

3.7 Nodulation

The number of nodules was counted from sample plants at 60 and 90 days after plantو and average was recorded.

3.8 Rain fall use efficiency and its effect on genotypes and NPK application

$$\frac{\text{Economic yield}}{\text{Rain fall amount}} \times 100$$

3.9 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 (1989). 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. Stability of groundnut genotypes were carried by Minitab statistical analysis program, Commonly used regression based stability model to assess significant GXE and to decide the stable genotype.

Table (5): Single ANOVA table

Source of variation	DF	MS	EMS
Replication	r-1	MS_1	
Treatments	t-1	MS_2	
Error	(r-1) (t-1)	MS_3	
Total	Rt-1		

Table (6): Combined ANOVA table

Source of variation	DF	MS	EMS
Year	y-1	MS_1	
L(Y)	Y(l-1)	MS_2	
R(LY)	Yl(r-1)	MS_3	
Treatment	t-1	MS_4	
Y T	(y-1)(t-1)	MS_5	
L T(Y)	Y(l-1)(t-1)	MS_6	
Error	Y(r-1)(t-1)	MS_7	
Total	LY(rt-1)	$MS_1+MS_2+\ldots+MS_7$	

Table (7): Interaction ANOVA table

Source of variation	DF	MS	EMS
Replication	r-1	MS_1	
Factor A	A-1	MS_2	
Factor B	B-1	MS_3	
AB	(A-1) (B-1)	MS_4	
Error	(AB-1) (R-1)	$MS_1+MS_2+\ldots+MS_6$	

CHAPTER FOUR

RESULTS AND DISCUSSION

Results of the combined analysis over seasons and locations are presented in this chapter , while ANOVA for each location and season are shown in appendix.

4.1 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 (8 and 9) 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, hundreds seed weight, number of pod 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 micr-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. However, Chinaware *et al.,* (1995) found insignificant effect of NPK on peanut yield. 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 were; 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 (8): Yield component (Shelling%, harvest index and hundred) seed weight

genotypes	Shelling%		Harvest Index		100 seed weight	
	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 (9):Yield and its component (Number of pods per plant, hay yield, pod yield and Maturity %)

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**

4.2 Value cost ratio (VCR) of NPK fertilizer micro-dose

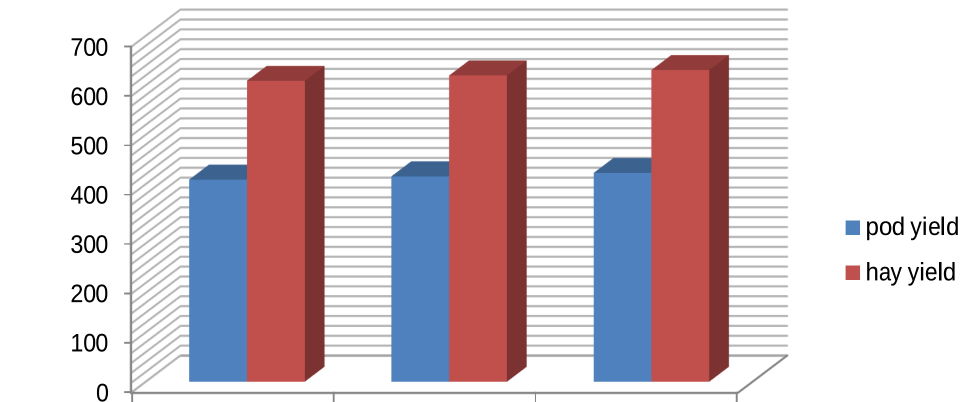
Value cost ratio (VCR) of NPK fertilizer micro-dose are presented in Table (10). fertilizer use is profitable with VCR of 2.7 (FAO, 2005), VCR were highest in Soderi 2.78 and ICGV89171 2.11 for pod yield and Soderi 1.36 and ICGV93255 1.33 for hay yield. Adding the hay value to the pod value increased the VCR. It is worth mentioning that hay yield is a valuable agricultural bi-product which is utilized for animal feed in the dry months of the year. Elgailani *et. al* (2015) they were recorded that The highest economic return, FUE, and VCR corresponded to the treatment which produced the highest grain and total biological yield in each crop. Low fertilizer application rates have been related to very high VCR owing to the small cost of the treatment and the associated high rate of response (Roy *et al*., 2006).

Table (10): Value cost ratio (VCR) of NPK fertilizer micro-dose

Genotypes	Hay yield VCR	Pod yield VCR
1-ICGV92121	-0.23	-0.88
2-ICGV86744	-1.83	-1.50
3-ICGV93255	1.33	1.78
4-ICGV89171	1.13	2.11
5-Soderi	1.36	2.78
6-Gibiesh	0.38	0.33

*15-15-15 NPK fertilizer price is 250 SDG per 50 kg sack (5 SDG/Kg);

** Note: Groundnut price according to Obeid Auction Market, 2012–2013, are 5 SDG\ kg



	Control	Grand mean	Treatment
pod yield	408.9	415.6	422.4
hay yield	608.8	619.7	630.6

Figure (1): pods and hay yield among genotypes and application of NPK micro doses

4.2 Seed quality of genotypes and treatments:

4.2.1 Oil content of treatments:

The data pertaining to the oil yield are presented in Table (11). 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 were 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 were 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.

4.2.2 Protein content % of treatments:

Protein content % of genotypes and treatments showed in Table (11). 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 acids structure and fatty acids. El-Habbasha *et.al.*, (2005) showed that increasing P levels increased oil, protein, and phosphorus contents of groundnut.

Table (11): Protein % and Oil %

genotypes	Protein %		Oil %	
	Control	With NPK	Control	With NPK
1-ICGV92121	22	24	43	50
2-ICGV86744	25	26	47	55
3-ICGV93255	23	23	49	49
4-ICGV89171	24	26	48	56
5-Soderi	29	28	50	57
6-Gibiesh	27	30	46	48
Mean	25	26	47	53
SE ±	0.73**	0.73**	1.2**	1.2**
C.V	6.4	6.4	17.6	17.6
Interaction	25	26.5*	46	54**

4.3 Morphological traits

4.3.1 Dry matter accumulation

The dry matter accumulation during growing period is presented in Table (12) and figure (2 and 3). Total dry matter accumulated by all stages of the season were highly significant (p=0.05) differences among treatments. in the Early season i.e. thirty days from planting the highest dry matter accumulated was in the genotypes ICGV892121 with NPK treatment while the lowest was accumulated by ICGV92121 without NPK application. In the mid of season i.e. sixty days and end of season i.e. ninety days from planting the highest dry matter was accumulated in ICGV89171 with NPK treatment and the lowest was accumulated in ICGV93255 without NPK treatment. The mean of dry matter accumulation treated by NPK was 2, 15 and 26 gm while without treated

2, 12 and 20 gm at 30, 60 and 90 days after planting respectively. The NPK micro dose application increased the dry matter accumulation, as general the total dry matter was positively affected by NPK micro dose application. Sastry et al. (1980), recorded progressive increase in dry matter up to harvest. The increase, however, was very rapid up to 90 days. On an average the weight of each plant at harvest ranged from 40 to 60 g in bunch types. The excess dose of NPK application was reported to increase dry matter production significantly with enhanced rate of NPK supply at various stages of growth up to harvest.. This is in conformity with the finding of Barik et al. (1998).

Table (12): Dry matter accumulation (gm) per plant at 30, 60 and 90 days after planting

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	1.76	12.97	23.10	2.57	15.72	28.96
2-ICGV86744	1.92	13.00	19.00	1.94	15.58	24.26
3-ICGV93255	1.79	10.34	17.54	1.83	12.12	20.80
4-ICGV89171	2.04	11.59	21.73	2.50	17.04	29.03
5-Soderi	1.88	12.16	19.80	2.08	16.48	28.68
6-Gibiesh	1.84	11.70	21.88	1.92	15.79	27.29
Mean	1.87	11.96	20.51	2.14	15.46	26.50
SE ±	0.08**	0.61**	1.08**	0.08**	0.61**	1.08**
C.V	16.2	17.80	18.50	16.2	17.80	18.50

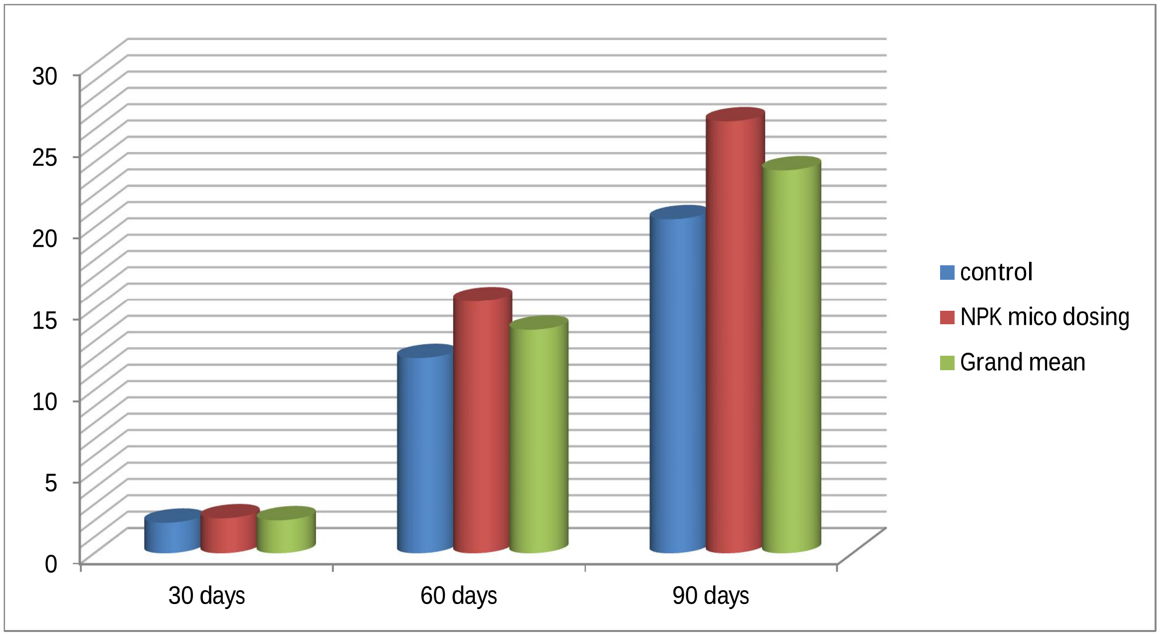
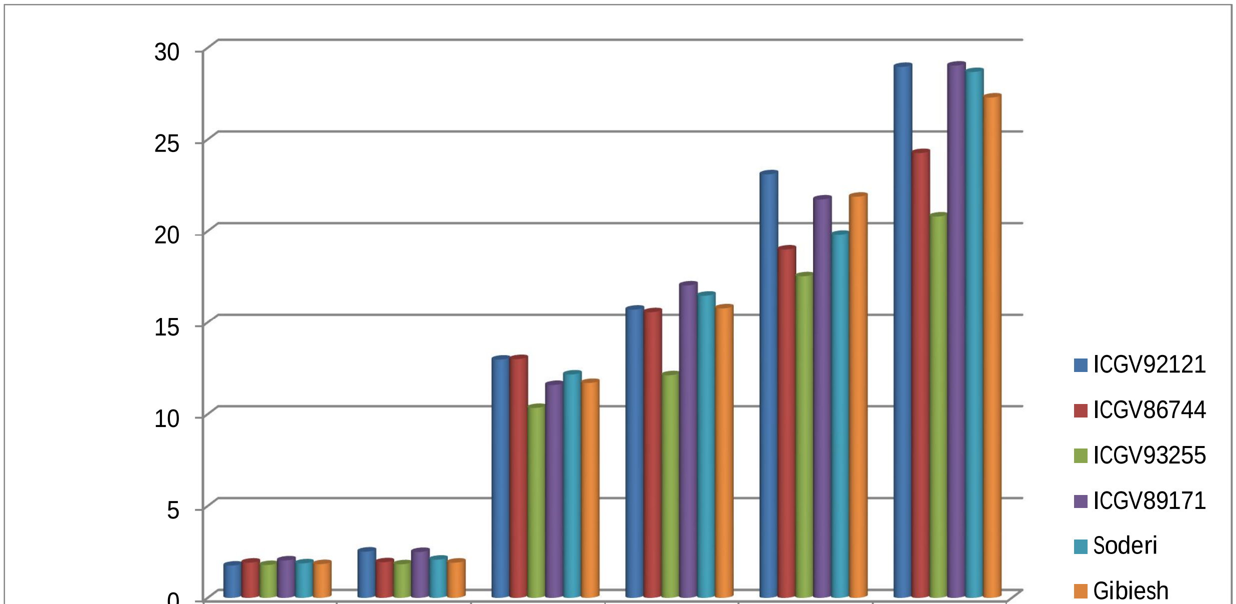


Figure (2): Effect of NPK micro dosing on dry matter (gm\plant) accumulation during growth period (30, 60 and 90 days after plant



	30 days wihout NPK	30 days with NPK	60 days without NPK	60 days without NPK	90 days without NPK	`90 days with NPK
ICGV92121	1.76	2.52	12.97	15.72	23.1	28.96
ICGV86744	1.92	1.94	13	15.58	19	24.26
ICGV93255	1.79	1.83	10.34	12.12	17.54	20.8
ICGV89171	2.04	2.5	11.59	17.04	21.73	29.03
Soderi	1.88	2.08	12.16	16.48	19.8	28.68
Gibiesh	1.84	1.92	11.7	15.79	21.88	27.29

Figure (3): Effect of NPK micro dose on dry matter of groundnut genotypes (gm\plant) accumulation during growth period (30, 60 and 90 days after plant).

4.3.2 Dry matter distribution %

The percentage of dry matter distribution among different organs for the different genotypes throughout the season is presented in Table (13 to 15). Until 60 days from planting all of the assimilates were accumulated in the roots, shoots and the leaves. Sixty days from planting pods started to develop and absorb considerable amount of the dry matter produced. At 90 days, pods become the major sink of the assimilates produced. Across most of the development stages dry matter (%) distribution was not significant among genotypes. However, at 60 days after planting ICGV89171, Sodiri and Gubiesh without micro-dose treatment showed significant diversion of assimilates in the root, while Sodiri with NPK treatment recorded the least. At 60 days from planting ICRISAT lines showed that significant proportion of the dry matter was accumulated into the leaves. Near the end of the season all genotypes accumulated between 38 to 44 % of the assimilates into the pods. Though differences were not significant, Sodiri recorded the highest proportion for assimilates diversion into pods. Bunting and Anderson, (1960) who reported that nearly 45-50 % of total dry matter produced in a plant was accumulated in kernels and 16 % in shells, 20 % in stems, 11 % in leaves and 1 % roots.

Table (13): Dry matter distribution % per plant at 30 days after planting

Genotypes	Without NPK treatment			With NPK treatment		
	roots	shoots	leaves	roots	shoots	leaves
1-ICGV92121	7.0	39.5	52.5	6.4	43.8	49.9
2-ICGV86744	6.4	40.5	51.7	6.3	38.6	54.8
3-ICGV93255	6.6	38.7	55.6	7.0	40.8	52.4
4-ICGV89171	7.9	39.9	52.4	7.7	40.6	50.0
5-Soderi	6.9	41.4	51.9	6.8	39.0	53.7
6-Gibiesh	6.3	40.8	52.8	6.8	39.2	53.3
Mean	6.9	40.1	52.8	6.8	40.3	52.4
SE ±	0.24^{ns}	0.80^{ns}	0.59^{ns}	0.24^{ns}	0.80^{ns}	0.59^{ns}
C.V	13.9	7.9	4.5	13.9	7.9	4.5

Table (14): Dry matter distribution % per plant at 60 days after planting

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	2.4	31.3	42.7	24.0	2.8	31.0	40.8	26.1
2-ICGV86744	2.5	31.6	42.9	23.7	2.4	29.9	40.9	26.2
3-ICGV93255	2.7	31.6	46.5	19.3	2.6	32.3	43.2	21.7
4-ICGV89171	3.2	30.2	46.9	19.4	2.5	29.4	42.2	26.1
5-Soderi	3.3	32.3	43.7	20.5	2.0	29.7	43.7	24.4
6-Gibiesh	3.1	32.6	45.1	17.7	2.2	32.4	42.4	22.9
Mean	2.9	31.6	44.6	20.8	2.4	30.7	42.2	24.6
SE ±	0.13^{*}	0.48^{ns}	0.49**	0.75**	0.13^{*}	0.48^{ns}	0.49**	0.75**
C.V	18.8	6.1	4.6	13.3	18.8	6.1	4.6	13.3

Table (15): Dry matter distribution % per plant at 90 days after planting

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	1.9	22.0	29.9	44.8	1.8	26.0	31.1	40.1
2-ICGV86744	2.1	24.6	30.0	41.6	1.8	25.1	30.7	41.2
3-ICGV93255	2.1	26.2	28.9	43.0	2.2	25.1	30.8	43.3
4-ICGV89171	2.0	26.0	32.6	38.3	1.5	23.1	30.4	40.8
5-Soderi	2.3	24.2	30.9	42.5	1.7	25.6	29.4	40.6
6-Gibiesh	2.3	23.8	30.4	41.2	1.8	23.0	28.4	43.2
Mean	2.12	24.47	30.45	41.9	1.8	24.7	30.1	41.5
SE ±	0.10^{ns}	0.50^{ns}	0.70^{ns}	0.90^{ns}	0.10^{ns}	0.50^{ns}	0.70^{ns}	0.90^{ns}
C.V	18.7	8.2	8.7	8.4	18.7	8.2	8.7	8.4

4.3.3 Leaf area

The seasonal pattern of leaf area development is presented in Table (16) and figure (4 and 5). Leaf area increased rapidly up to 90 days from planting. Thereafter, it started increase but at slower rate in all treatments. Non significant differences were observed among genotypes and NPK micro-dosing in leaf area at early stage of development (30 days after planting). At this stage the highest leaf area of about 278.4 cm^2 was attained by ICRISAT line ICGV89171 without NPK micro dosing treatment and the lowest of 149.5 cm^2 by ICGV93255 with NPK treatment. At sixty days after planting the leaf area was significant increase, the highest recorded by genotypes ICGV89171 with NPK treatment while the lowest by line ICGV93255 without treatment. At the end of season i.e. Ninety days after planting the leaf area was high significant differences among genotypes, the maximum leaf area recorded by line ICGV92121 with NPK treatment, the widely grown genotypes and known in the area i.e. Sodiri and Gubiesh recorded a leaf area between 1006.7 to 1040.4 cm^2 without treatment and 1240.8 t0 1352.0 cm^2 with NPK treatment. In all genotypes and treatments maximum leaf area was attained at 90 days after planting. Mean of leaf area for NPK treatment across the seasons and location was 200 cm^2 while 180 cm^2 without treatment at 30 day after planting. At mid of season 60 days after planting, NPK treatment was 1080 cm^2 and without treatment was 800 cm^2. At the end of season 90 days after planting the mean of genotypes treated by NPK was 1200 cm^2 while without treatment was 1000 cm^2. At all stages of crop the NPK treatment increase the leaf area 20%. It coincided with maximum dry matter production, indicating that dry matter production is highly influenced by the photosynthetic area. Similar results were reported by Maeda, (1971a). He observed that the value of leaf area in Spanish types was 500 to1500 cm^2. In this study mean leaf area was from 206 to 1050.8cm^2 per plant with NPK treatment and 224 to 1247.5 cm^2 without NPK treatment by the end of the growing period. Cox *et al.* (1992) reported that application of nitrogen in the form of urea in two equal splits at the time of sowing and at 30 days after plant significantly increased the dry matter accumulation with each increment levels. Studies on the response of three levels of nitrogen *viz.*, 0, 15 and 30 kg ha-1 to groundnut during summer season was made and the results revealed that application of N at higher dose did not significantly improve the dry matter accumulation and yield attributes at harvest (Chawale *et al.*, 1993).

Table (16): Leaf area (cm^2) per plant at 30, 60 and 90 days after planting

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	172.67	868.2	1365.5	165.6	995.1	1570.1
2-ICGV86744	192.6	931.5	811.3	275.7	1120.9	1190.8
3-ICGV93255	248.7	743.8	983.5	149.5	914.8	983.0
4-ICGV89171	278.4	878.0	1097.2	224.9	1278.8	1148.3
5-Soderi	155.1	766.8	1040.4	213.3	1000.7	1352.0
6-Gibiesh	188.3	838.6	1006.7	215.0	1231.5	1240.8
Mean	205.96	837.82	1050.8	224.06	1090.3	1247.5
SE ±	22.5^{ns}	56.8*	50.5**	22.5^{ns}	56.8*	50.5**
C.V	41.7	23.6	17.6	41.7	23.6	17.6

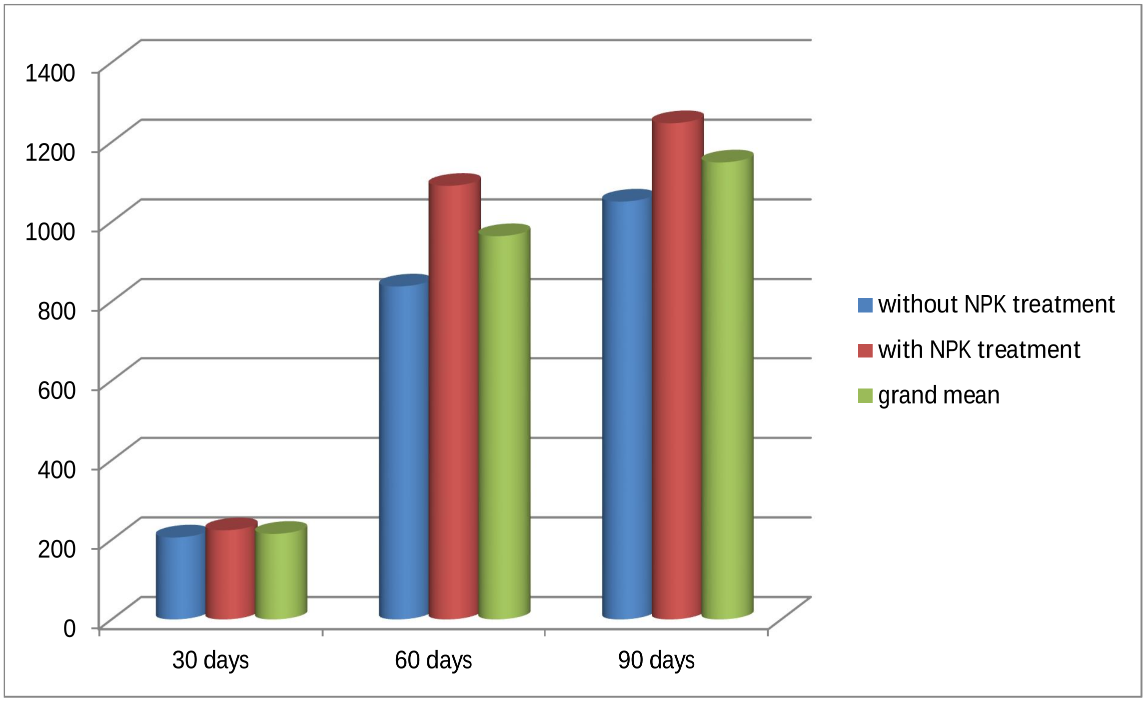
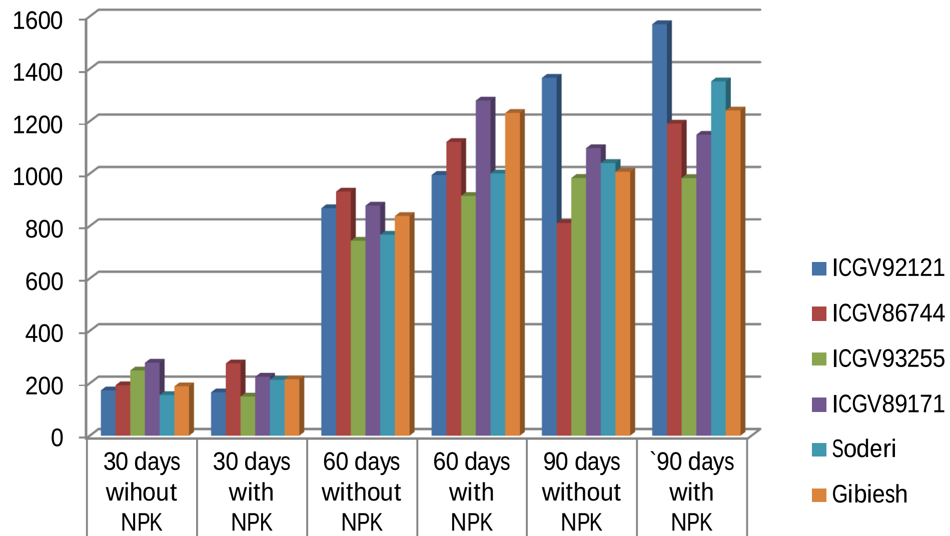


Figure (4): Effect of NPK micro dosing treatment on Leaf area (cm^2/plant) during growth period (30, 60 and 90 days after plant).



	30 days wihout NPK	30 days with NPK	60 days without NPK	60 days with NPK	90 days without NPK	`90 days with NPK
ICGV92121	172.7	165.6	868.2	995.1	1365.5	1570.1
ICGV86744	192.6	275.7	931.5	1120.9	811.3	1190.8
ICGV93255	248.7	149.5	743.8	914.8	983.5	983
ICGV89171	278.4	224.9	878	1278.8	1097.2	1148.3
Soderi	155.1	213.3	766.8	1000.7	1040.4	1352
Gibiesh	188.3	215	838.3	1231.5	1006.7	1240.8

Figure (5): Effect of NPK micro dosing on Leaf area of groundnut genotypes under study (cm^2/plant) during growth period (30, 60 and 90 days after plant)

4.3.4 Growth analysis

Seasonal and varietal variation of LAI, SLA, CGR, RGR and NAR is presented in Table (17 to 19). Across the season, significant differences were observed among genotypes and treatments for LAI at 60 and 90 DAP, CGR at 30 and 60 DAP and SLA at 90 DAP. No significant differences on RGR and NAR between treatments. Mean seasonal pattern of these traits indicated that the maximum LAI and CGR were attained around 60 days after planting, whereas, NAR was kept consistently high up to the 60 days from planting where it started to decline. All these traits increased rapidly at the early period of growth reaching their maximum at around 60 days after planting and declined near harvest. Conversely SLA and RGR were high at the beginning the growth period and declined towards the end of crop maturity at 90 days after planting. Sanjeev, (1996) studied Spanish and Virginia type varieties of groundnut using growth techniques. Observation on LAI, GCR, RGR and NAR were taken at 30, 60, 90 (DAP) and at maturity. CGR increased as crop growth progressed and it was highest between 60 and 90 (DAP) in all studied cultivars except ALA1 and Kadiri 3 (Virginia type) where higher values were recorded between 90 (DAP) and maturity stage). RGR was highest in Kadiri 3 (Virginia type) between 60 and 90 DAP, whereas in ICGS 44 (Spanish type) between 30 and 60 days. NAR value was highest in Kadiri 3 variety between 90 DAP and maturity, and in AK 12 -24 (Spanish type) between 60 and 90 DAP. They concluded that LAI, RGR, NAR and CGR significantly affected pod yields in Chitra (Virginia type), had no definite trend in cultivars of the Spanish type. Jadhar and Narkhede (1980) reported that groundnut recorded higher dry matter accumulation, RGR, leaf area per plant and leaf area index with the application of 60 kg and 90 kg K2O ha-1 when compared to the control. Higher leaf area index in groundnut with application of 40 kg N ha-1 as compared to lower doses (20 kg ha-1) and control was also reported by Reddy et al. (1982). Application of 30 kg N-60 kg P_2O_5 /ha significantly enhanced the dry matter accumulation over control and the lowest fertilizer level of 20 kg N-40 kg P_2O_5/ ha during both the years. Further increase in fertilizer level up to 40 kg N-80 kg P_2O_5/ ha did not improve their growth parameters significantly over 30 kg N-60 kg P_2O_5/ha for all growth parameters. Application of nitrogen and phosphorus significantly enhanced the plant growth as manifested by increased dry matter accumulation, crop growth rate, initial relative growth rate at all the growth stages. Application of 30 kg N-60 kg P_2O_5 /ha brought about overall improvement in crop growth under the influence of nitrogen and phosphorus application which could be attributed to better environment for growth and development that might be due to increased availability of these nutrients to the crop plants. This could be supported by the fact that soil of experimental field was very poor in nitrogen and phosphorus. As evident from results, it can be clearly concluded that application of 30 kg N-60 kg P_2O_5 /ha as a basal dose was found adequate for initial pick up of growth, photosynthesis and dry matter accumulation. The results of the present investigation are in agreement with the finding of several researchers (Barik *et al.*, 1994; Ibrahim and Eleiwa, 2008) who also reported increase in the dry matter production, periodic CGR and initial RGR of crop due to basal application of nitrogen and phosphorus. Parasuraman *et al.* (1998) also reported that higher availability of plant nutrients leads to higher growth parameters in the fertilized treatments of groundnut.

Table (17): Crop growth rate (g/day/plant) per plant at 30, 60 and 90 days after plant

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.059	0.343	0.338	0.086	0.439	0.449
2-ICGV86744	0.064	0.362	0.212	0.064	0.446	0.289
3-ICGV93255	0.060	0.285	0.258	0.061	0.345	0.295
4-ICGV89171	0.068	0.320	0.308	0.083	0.422	0.420
5-Soderi	0.063	0.342	0.259	0.069	0.546	0.415
6-Gibiesh	0.061	0.329	0.337	0.063	0.418	0.393
Mean	0.063	0.330	0.285	0.071	0.436	0.377
SE ±	0.001**	0.02**	0.04^{ns}	0.001**	0.02**	0.04^{ns}
C.V	15.8	21.3	46.4	15.8	21.3	46.4

Table (18): Specific leaf area (cm^2/g/plant) per plant at 30, 60 and 90 days after plant

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	186.9	241.2	223.5	201.2	242.2	219.1
2-ICGV86744	191.1	235.5	179.6	218.2	266.4	226.2
3-ICGV93255	218.7	284.1	250.8	163.0	283.6	236.6
4-ICGV89171	205.3	254.1	227.9	163.4	253.9	177.3
5-Soderi	174.5	216.8	197.6	192.1	272.8	201.9
6-Gibiesh	194.4	250.7	191.6	195.1	280.7	212.6
Mean	195.2	247.1	211.8	188.8	266.6	212.3
SE ±	8.39^{ns}	12.1^{ns}	8.03*	8.39^{ns}	12.1^{ns}	8.03*
C.V	17.5	18.7	15.2	17.5	18.7	15.2

Table (19): Net assimilation rate (g/dm²/day) of groundnut genotypes and treatments at 30, 60 and 90 days after planting

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.00047	0.00018	0.00023	0.00038	0.00022	0.00020
2-ICGV86744	0.00044	0.00021	0.00018	0.00041	0.00019	0.00023
3-ICGV93255	0.00046	0.00018	0.00019	0.00046	0.00017	0.00022
4-ICGV89171	0.00046	0.00018	0.00020	0.00056	0.00021	0.00016
5-Soderi	0.00044	0.00021	0.00022	0.00048	0.00020	0.00015
6-Gibiesh	0.00052	0.00019	0.00017	0.00044	0.00020	0.00019
Mean	0.00047	0.00019	0.00020	0.00046	0.00020	0.00020
SE ±	0.032^{ns}	0.021^{ns}	0.019^{ns}	0.032^{ns}	0.021^{ns}	0.019^{ns}
C.V	17.4	14.2	20.1	17.4	14.2	20.1

4.4 Nodulation

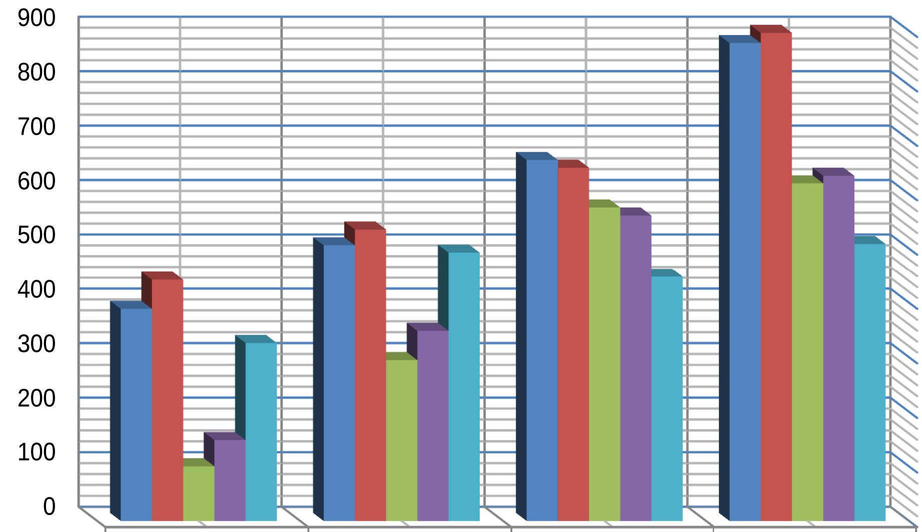
Nodules number is shown in Table (20). Mean number of nodules per plant was significantly different amongst genotypes and treatments at all period of growth. The highest nodules number (22.19 nodules/ plant) was recorded by Gubiesh with treatment; while the lowest number (16 nodules/ plant) was recorded by ICGV93255 without NPK treatment at 30 DAP. At the end of season the highest nodules was recorded by ICGV92121without NPK treatment (14.63) and the lowest by ICGV89171 with NPK treatment. Generally, during the early stages of growth and up to the beginning of maturity (60 DAP) there was a rapid increase in nodules number, thereafter; there is a slight decline was observed. During late stages most of assimilates are diverted to the developing fruits, which presumably reduce nitrogen fixation process. Similar results were reported by Venkateswarlu *et al,* (1991) who also found that the superior nodulation of Virginia cultivars became significant only 60 DAP when hypocotyls nodulation began. Genotypic variation in nodules number was also reported by several researchers, (Adlan and Mukhtar, 1999), who found that under different levels of nitrogen, no significant differences were detected in number of nodules for many Virginia types and Barberton. Kulkorni *et al*., (1986) reported that application of 50kg $P_2\,0_5$/ha increased number and weight of nodules of groundnut. Collins *et al*., (1986) observed that addition of phosphorus and sulphur increased nodule number on the sandy soil but not on the silt loam soil.

Table (20): Number of nodules per plant at 60 and 90 days after plant

Genotypes	Without NPK treatment		With NPK treatment	
	60	90	60	90
1-ICGV92121	16.03	14.63	21.34	11.34
2-ICGV86744	17.00	9.75	21.28	11.81
3-ICGV93255	15.97	8.81	22.19	9.38
4-ICGV89171	19.41	11.78	21.78	8.69
5-Soderi	18.91	10.91	21.34	9.16
6-Gibiesh	20.34	13.16	25.78	11.84
Mean	17.94	10.51	22.29	10.37
SE ±	0.95*	0.60*	0.95*	0.60*
C.V	18.8	21.9	18.8	21.9

4.5 Rain fall use efficiency and its effect on genotypes and NPK application

The rain fall efficiency and its effect showed in figure (6 and 7). Increase in amount of rain fall has positive effect on hay yield and pod yield, increase in both yield 12% with NPK application. Pod yield of groundnut and rainfall received during pod formation to maturity were positively correlated in a rain fed crop grown at semi-arid region of Andhra Pradesh in India (Subbaiah et al., 1974), our results are in agreement with these findings. Groundnut requiring average rainfall of 600-1200 mm per year under Senegal's climatic conditions is receiving 500-700 mm of rainfall per year (Badione, 2001). Dulvenbooden et al. (2002) reported that groundnut production in Niger is significantly determined by rainfall during July to September. Naing (1980) reported that rain fall was main factor determining yield in Myanmar. Liang Xuangquiang et.al. (1996) assessed the performance of fifteen peanut genotypes developed at ICRISAT in rain fed upland fields during autumn and spring seasons. During both seasons, the large seeded peanut variety ICGV 86742 gave significantly higher pod yield of 2.35 t ha-1 indicating no seasonal variation. Similar observation was also made by Patra et.al (1995). Popov (1984) and Ong (1986) showed poor relationship between groundnut yield and seasonal rainfall, high lighting the higher importance of rainfall distribution to groundnut yield than the quantum of rainfall.



	S1 L1	S1 L2	S2 L1	S2 L2
Hay yield control	388.7	506.1	662.8	877.6
Hay yield with NPK	442.4	535.1	648.6	896.3
Pod yield control	100.2	294.7	575.6	619.9
Pod yield with NPK	148.2	348.4	560.7	633.8
Amount of rain fall	326	492.5	448	508.5

Figure (6): Effect of rain fall on genotypes and NPK application

Note: S= Season$_{1, 2}$ L= Location$_{1, 2}$

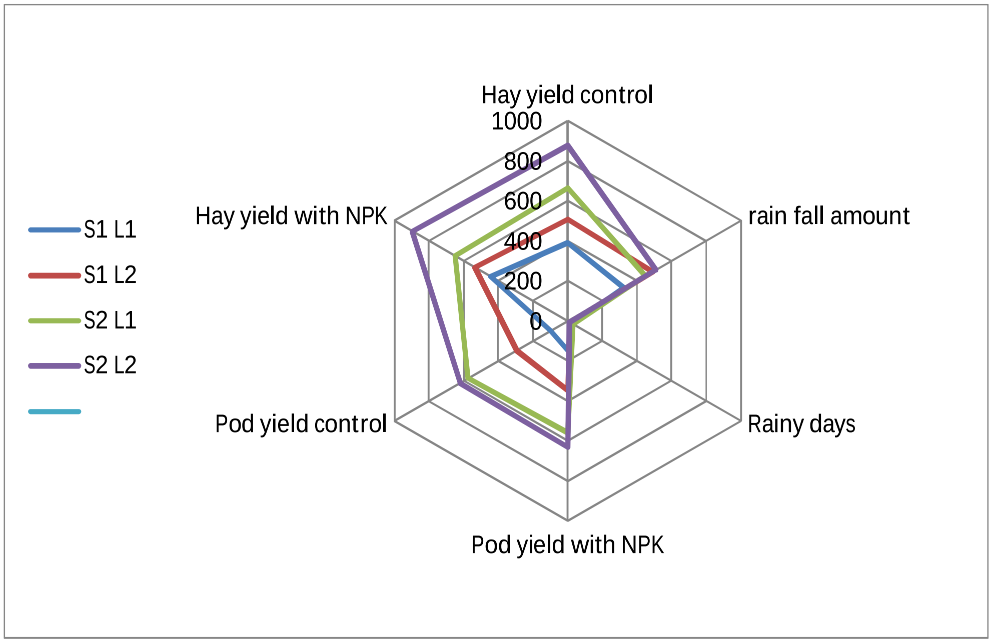


Figure (7): Rain fall use efficiency and its effect on genotypes and NPK application

Note: S= Season$_{1, 2}$ L= Location$_{1, 2}$

4.6 Correlations between physiological traits and amount rainfall at the end of season

Correlation coefficients between some physiological traits and monthly amount rainfall during different growth stages shown in table (21). At the end of season 90 days after plant high significant differences observed between monthly amount rainfall and TDM, CGR and LA and no significant with LA and SLA. There was a highly significant and positive correlation between leaf area and dry matter accumulation and between crop growth rate and leaf area index at all stages of crop. SLA was not significant at all sampling times. Suwapan Ratanarat and Prasart Kesawapitak (1998) they were conducted Nine sites of fertilizer trials were classed into 3 levels of rainfall intensity; 1200 mm/year.

Twelve treatment combinations of fertilizer N-P-K include 0-0-0, 0-9-6, 1.5-9-6, 3-0-6, 3-4-5-6, 3-9-0, 3-9-3, 3-9-6, 3-9-12, 3-18-6, 6-9-6 and 6-18-12 were arranged in RCB design with two replications. Results showed that the response of peanut yield to N application was markedly detected when the rainfall exceeded 1400 mm/year. The effect of P and K application on yield tended to increase in all zones. However, the combinations of N P and K at recommended or high rates increase yield significantly when compared to control (0-0-0). The degrees of NPK responses were positively associated with the rainfall intensity.

Table(21):Correlations between different physiological traits and third month amount rainfall at 90 days after planting

	Rainfall	LA	TDM	CGR
Rainfall				
LA	0.323607^{ns}			
TDM	0.490504*	0.9017**		
CGR	0.93205**	0.2128^{ns}	0.5157**	
SLA	-0.17454^{ns}	-0.184^{ns}	-0.560*	-0.4914^{ns}

Ns = not significant, * = significant (5%), ** = highly significant (1%)

4.7 Effect of NPK micro dose on Correlations between physiological traits and hay and pod yield

Effect of NPK treatment on Correlations between physiological traits and hay and pod yield at the end of season is presented in Table (22 and 23). At tow cases, NPK micro doses application or control the correlation was same, high significant correlation was observed between LA and TDM, CGR, and SLA. The significant differences were found between TDM and CGR and LA, CGR and LA, LA and SLA and between pod yield and hay yield but the correlation between pod and hay yield increased by NPK micro doses application. Enyi (1977), observed Positive correlations of pod yield with leaf area index were observed. Subrahmaniyan *et. al* (2000), Increasing the NPK rate to 100% of the recommended doses increased growth and yield parameters and a pod yield.

Table (22): Correlations between different physiological traits and hay and pod yield without NPK treatment:

	LA	TDM	CGR	SLA	Pod yield
LA					
TDM	0.541**				
CGR	0.401**	0.798**			
SLA	0.438**	0.061^{ns}	0.274^{ns}		
Pod yield	0.092^{ns}	0.192^{ns}	-0.124^{ns}	-0.065^{ns}	
Hay yield	0.163^{ns}	0.049^{ns}	-0.122^{ns}	0.009^{ns}	0.484**

Ns = not significant * = significant (5%) ** = highly significant (1%)

Table (23): Correlations between different physiological traits and hay and pod yield with NPK treatment:

	LA	TDM	CGR	SLA	Pod yield
LA					
TDM	0.463**				
CGR	0.323*	0.820**			
SLA	0.488**	0.10^{ns}	-0.088^{ns}		
Pod yield	-0.02^{ns}	0.108^{ns}	-0.091^{ns}	0.014^{ns}	
Hay yield	-0.18^{ns}	-0.098^{ns}	-0.109^{ns}	-0.053^{ns}	0.579**

Ns = not significant * = significant (5%) ** = highly significant (1%)

4.8 Correlations between physiological traits, pod and hay yield and maximum and minimum temperature

Correlations between physiological traits, pod and hay yield and maximum and minimum temperature presented in Table (24). The high significant differences were observed between maximum temperatures and LA, TDM and SLA and negative significant correlation between maximum, minimum temperature and CGR, LA, pods and hay yield. Reddy and Reddy (2003), also confirmed that mean maximum temperature had significant negative correlation with yield and yield attributes of groundnut. Meena *et.al* (2015) were observed the fertility treatments produced significantly higher crop growth rate and yields than the treatments receiving no fertilizer application. However, the crop uses maximum temperature in the month of June for better growth and yield. Application of 30 kg N-60 kg P2O5 ha-1 was optimum for growth and yield of the crop.

Table (24): Correlations between different physiological traits, pod and hay yield and maximum and minimum temperature

Temperature	LA	TDM	CGR	SLA	Pod yield	Hay yield
maximum	0.69**	0.34*	-0.84**	0.660**	-0.7*	-0.4*
minimum	-0.37*	-0.74**	-0.40*	0.708**	-0.7*	-0.9*

Ns = not significant * = significant (5%) ** = highly significant (1%)

4.9 Stability of genotypes

The performance of genotypes on environmental conditions, resulting in a strong genotype and environment (GE) interaction showed in (25 to 28). There are no significant differences were observed between genotypes in stimated of shelling percent and hay yield but the pod yield has significant differences, Soderi recorded best estimated pod yield 322.4 kg/ha. The best Environment mean and Environmental index of shelling%, hay yield and pod yield recoded at Faris in 2012, when were compared over seasons and locations for performance of genotypes season 2012 and Faris location were best. Ali et al. (2001) reported that top yielding entries BM-28 and ICGV-86550 were stable and found desirable. Sojitra and Pethani (1998) reported the importance of nonlinear components of variance for 1000 pod weight and shelling percentage. Small pod variety J-11 was reported widely adaptable and other bold pod varieties GG-2 and Girnar of groundnut were insensitive to change in environment. Bentur et al. (2004) studied the stability of 13 large seeded groundnut cultivars for pod yield and yield components. Significant genotype x environment interaction was recorded for pod yield, number of pods, shelling percentage, kernel weight and sound mature kernel percentage. Five cultivars were stable for shelling percentage across different environments.

Table (25):Estimates of stability of pods yield

Genotypes	Without NPK treatment				With NPK treatment			
	Mean	S²d	P %	R² %	Mean	S²d	P %	R² %
1-ICGV92121	396.2	-7801	100	97.3	379.6	-8922.0	100	98.8
2-ICGV86744	525.9	4583.4	23.2	92.4	505.0	-5509.3	100	97.1
3-ICGV93255	430.0	-6106.6	100	97.3	461.8	13573.8	9.4	88.3
4-ICGV89171	361.4	327.8	35.8	81.5	398.8	-2047.3	100	84.7
5-Soderi	272.6	6789.5	18.5	6.9	322.4	22844.4	3.7*	3.1
6-Gibiesh	467.0	-5346.0	100	97.0	472.7	6228.9	19.6	87.8

Table (26):Estimates of stability of hay yield

Genotypes	Without NPK treatment				With NPK treatment			
	Mean	S²d	P %	R² %	Mean	S²d	P %	R² %
1-ICGV92121	567.6	-18050.9	100	97.3	554.3	-17396	100	93.0
2-ICGV86744	786.7	-15928.9	100	98.6	678.1	-7333.0	100	93.0
3-ICGV93255	623.1	-18960.0	100	100.0	703.4	-9927.5	100	92.9
4-ICGV89171	525.3	-9632.3	100	83.1	593.0	-8697.3	100	64.3
5-Soderi	419.4	-16652.6	100	30.6	500.4	-7378.1	100	9.5
6-Gibiesh	730.5	-10303.1	100	94.3	734.0	2120.6	33	88.5

Table (27):Estimates of stability of shelling %

Genotypes	Without NPK treatment				With NPK treatment			
	Mean	S^2d	P %	R^2 %	Mean	S^2d	P %	R^2 %
1-ICGV92121	58.3	-4.3	100	87.8	57.8	17.7	11.4	11.8
2-ICGV86744	58.3	-12.1	100	86.8	58.9	-6.7	100	64.8
3-ICGV93255	53.1	4.2	28	22.7	60.2	-9.9	100	88.0
4-ICGV89171	55.3	28.5	5.6	34.2	58.2	7.0	23.3	16.2
5-Soderi	57.8	-8.7	100	55.8	58.2	0.3	36.4	3.2
6-Gibiesh	56.3	0.9	34.8	52.1	59.6	-12.9	100	86.0

Table (28): Environment mean and Environmental index of shelling%, hay yield and pod yield

Environments	Shelling mean	Shelling index	Pod yield mean	Pod yield index	Hay yield mean	Hay yield index
Elobeid 2011	53.4	-4.3	149.26	-266.87	415.5	-202.4
Elobeid 2012	58.0	0.27	564.8	148.69	655.6	37.6
Faris 2011	59.2	1.48	323.6	-92.51	513.8	-104.1
Faris 2012	60.3	2.59	626.8	210.69	886.9	268.9

Ns = not significant, * = significant (5%), ** = highly significant (1%)

CONCLUSIONS AND RECOMMENDATIONS:

This study showed that it is possible to increase the productivity of groundnut through NPK micro-dose treatment. The application of NPK micro-dose significantly influenced genotypes yields (pod and hay) and seed quality (protein and oil content). Use of a compound fertilizer NPK (15-15-15) at a lower rate (0.6 g/hole) is recommended for groundnut cultivated under the sandy rain-fed conditions of Western Sudan. The application increase productivity 12%. 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. The Sodiri with NPK treatment genotypes has significant stability of pod yield and gave best value cost ratio for pod and hay yield compared with all genotypes under study. Increase in amount of rain fall has positive effect on hay yield and pod yield, increase in both yield 12% with NPK application.

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Appendices

Appendix (1): Shelling%, harvest index and hundred seed weight at Elobeid season 2011

genotypes	Shelling%		Harvest Index		100 seed weight	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	47.1	54.6	27.3	22.1	46.5	47.3
2-ICGV86744	54.1	55.2	25.4	26.7	31.0	30.9
3-ICGV93255	51.8	53.2	27.2	29.7	31.0	29.5
4-ICGV89171	47.5	57.6	37.3	28.8	30.8	31.4
5-Soderi	55.4	56.0	27.8	23.8	30.1	31.2
6-Gibiesh	52.8	56.0	27.2	24.8	29.6	30.3
Mean	51.5	55.4	28.7	26.0	33.2	33.4
SE ±	1.6^{ns}	1.6^{ns}	2.3^{ns}	2.3^{ns}	0.73**	0.73**
C.V	12.0	12.0	28.6	28.6	8.8	8.8
Interaction	50.9	55.1	27.4	26.0	33.0	33.1

Appendix (2): Number of pods per plant and hay and pod yield at Elobeid season 2011

genotypes	Pods/plant		Hay yield (kg/ha)		Pod yield (kg/ha)	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	13.3	16.8	407.8	466.2	134.6	140.5
2-ICGV86744	14.5	14.8	444.5	438.9	145.4	125.8
3-ICGV93255	18.3	14.1	343.1	366.1	124.1	141.3
4-ICGV89171	15.6	17.6	355.0	413.9	191.7	165.8
5-Soderi	11.2	15.6	439.2	498.9	164.3	166.8
6-Gibiesh	18.0	18.8	342.5	470.6	142.0	149.0
Mean	15.1	16.6	388.7	442.4	150.4	148.2
SE ±	9.94^{ns}	9.94^{ns}	33.6^{ns}	33.6^{ns}	9.5^{ns}	9.5^{ns}
C.V	23.8	23.8	32.3	32.3	25.6	25.6
Interaction	15.0	16.6	388.7	442.4	150.3	148.1

Appendix (3): Protein %, Oil % and Maturity **%** at Elobeid season 2011

genotypes	Protein %		Oil %		Maturity %	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	24	22	40	49	78.5	76.5
2-ICGV86744	27	25	44	52	76.0	86.0
3-ICGV93255	27	25	50	50	74.5	80.0
4-ICGV89171	25	24	46	57	84.0	90.5
5-Soderi	26	26	50	56	81.0	81.5
6-Gibiesh	27	27	43	48	78.5	83.0
Mean	26	24.8	45.5	52	78.8	82.9
SE ±	0.74*	0.74*	1.09*	1.09*	1.3**	1.3**
C.V	11.9	11.9	14.3	14.3	6.2	6.2
Interaction	26	24,4	45	51	78.7	82.9

Appendix (4): Shelling%, harvest index and hundred seed weight at Elobeid season 2012

genotypes	Shelling%		Harvest Index		100 seed weight	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	63.4	52.8	43.1	44.7	32.7	34.9
2-ICGV86744	59.0	62.5	40.7	45.2	29.0	29.0
3-ICGV93255	59.5	65.1	40.9	42.6	27.0	30.4
4-ICGV89171	55.1	58.5	37.6	39.5	32.4	35.6
5-Soderi	60.0	60.1	51.5	46.2	28.2	30.2
6-Gibiesh	55.3	59.5	42.0	44.2	28.9	28.5
Mean	58.7	59.8	42.6	43.7	29.7	31.4
SE ±	1.84^{ns}	1.84^{ns}	1.5^{ns}	1.5^{ns}	0.62^{**}	0.62^{**}
C.V	12.4	12.4	13.9	13.9	8.2	8.2
Interaction						

Appendix (5): Number of pods per plant and hay and pod yield at Elobeid season 2012

genotypes	Pods/plant		Hay yield (kg/ha)		Pod yield (kg/ha)	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	12.2	14.0	523.8	481.1	310.4	296.6
2-ICGV86744	15.9	18.3	596.8	390.3	361.4	387.6
3-ICGV93255	17.1	17.3	474.0	570.8	241.5	154.3
4-ICGV89171	13.0	18.6	364.4	556.6	211.8	360.5
5-Soderi	11.0	11.3	405.2	533.1	360.8	521.6
6-Gibiesh	13.9	16.5	672.6	678.9	282.1	370.0
Mean	13.9	16.0	506.1	535.1	294.7	348.4
SE ±	0.84**	0.84**	54.2^{ns}	54.2^{ns}	36.8^{ns}	36.8^{ns}
C.V	22.4	22.4	41.6	41.6	45.8	45.8
Interaction						

Appendix (6): Protein %, Oil % and Maturity **%** at Elobeid season 2012

genotypes	Protein %		Oil %		Maturity %	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	20	20	42	52	81.5	79.5
2-ICGV86744	23	29	47	50	82.5	85.0
3-ICGV93255	24	22	48	50	88.0	86.5
4-ICGV89171	25	26	47	56	80.5	80.5
5-Soderi	24	28	50	56	85.0	87.0
6-Gibiesh	28	31	46	49	81.0	83.5
Mean	24	26	46.7	52.2	83.1	83.7
SE ±	0.77**	0.77**	1.2*	1.2*	0.62**	0.62**
C.V	15.2	15.2	13.1	13.1	3.0	3.0
Interaction	24	26	46	52	81	83.5

Appendix (7): Shelling%, harvest index and hundred seed weight at Faris season 2011

genotypes	Shelling%		Harvest Index		100 seed weight	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	61.6	63.3	51.5	50.0	46.3	46.3
2-ICGV86744	57.4	55.9	47.2	43.9	38.8	37.8
3-ICGV93255	50.6	59.9	49.6	48.8	41.6	40.1
4-ICGV89171	63.7	53.3	46.7	45.3	42.9	44.7
5-Soderi	55.0	61.7	45.9	41.5	36.4	33.0
6-Gibiesh	54.1	60.1	46.1	46.2	36.9	32.2
Mean	57.1	59.0	47.8	46.0	40.5	39.0
SE ±	2.2^{ns}	2.2^{ns}	1.9^{ns}	1.9^{ns}	0.31**	0.31**
C.V	15.2	15.2	16.2	16.2	3.1	3.1
Interaction						

Appendix (8): Number of pods per plant and hay and pod yield at Faris season 2012

genotypes	Pods/plant		Hay yield (kg/ha)		Pod yield (kg/ha)	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	40.4	34.3	569.5	536.1	582.8	539.6
2-ICGV86744	26.9	31.5	791.7	777.8	634.7	640.6
3-ICGV93255	19.8	23.9	680.6	861.1	623.7	792.0
4-ICGV89171	28.1	33.9	666.8	722.3	573.3	592.2
5-Soderi	30.5	36.8	472.2	375.0	370.9	276.8
6-Gibiesh	28.7	35.2	795.8	619.5	638.4	522.2
Mean	29.1	32.6	664.0	648.6	570.6	560.6
SE ±	2.2^{ns}	2.2^{ns}	54.9^{ns}	54.9^{ns}	33.8**	33.8**
C.V	29.0	29.0	33.5	33.5	24.0	24.0
Interaction						

Appendix (9): Protein %, Oil % and Maturity **%** at Faris season 2011

genotypes	Protein %		Oil %		Maturity %	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	22	25	44	49	83.5	84.5
2-ICGV86744	25	26	45	57	90.0	86.5
3-ICGV93255	27	24	47	51	85.5	86.5
4-ICGV89171	23	23	50	55	88.0	83.0
5-Soderi	27	27	47	56	84.5	85.5
6-Gibiesh	27	29	44	50	89.0	89.5
Mean	25.7	25.7	46	53	86.8	85.9
SE ±	0.80*	0.80*	1.2**	1.2**	0.51**	0.51**
C.V	10.9	10.9	12.7	12.7	2.4	2.4
Interaction	25.8	25.4	44	52	86.6	85.5

Appendix (10): Shelling%, harvest index and hundred seed weight at Faris season 2012

genotypes	Shelling%		Harvest Index		100 seed weight	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	61.2	60.7	40.8	42.7	40.2	42.6
2-ICGV86744	62.9	62.1	42.0	42.3	37.0	39.3
3-ICGV93255	54.3	62.8	46.2	41.7	36.5	37.4
4-ICGV89171	55.0	63.5	37.6	41.0	40.4	38.4
5-Soderi	60.8	55.0	36.9	40.0	34.9	35.1
6-Gibiesh	63.2	63.1	42.4	40.5	37.7	35.0
Mean	59.6	61.2	41.0	41.4	37.8	38.0
SE ±	1.73^{ns}	1.73^{ns}	1.54^{ns}	1.54^{ns}	0.63**	0.63**
C.V	11.5	11.5	14.9	14.9	6.7	6.7
Interaction						

Appendix (11): Number of pods per plant and hay and pod yield at Faris season 2012

genotypes	Pods/plant		Hay yield (kg/ha)		Pod yield (kg/ha)	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	24.7	41.4	769.4	733.9	557.3	541.7
2-ICGV86744	22.3	28.5	1313.9	1105.6	962.5	840.9
3-ICGV93255	20.7	30.3	994.7	1015.6	730.6	759.6
4-ICGV89171	25.4	40.8	715.0	679.5	468.9	476.7
5-Soderi	30.0	47.6	361.7	594.5	194.4	334.7
6-Gibiesh	26.7	43.5	1111.1	1248.4	805.6	849.4
Mean	25.0	38.7	877.7	896.3	619.9	633.8
SE ±	2.56**	2.56**	87.7**	87.7**	63.0**	63.0**
C.V	32.2	32.2	39.6	39.6	40.2	40.2
Interaction						

Appendix (12): Protein %, Oil % and Maturity **%** at Faris season 2012

genotypes	Protein %		Oil %		Maturity %	
	Control	With NPK	Control	With NPK	Control	With NPK
1-ICGV92121	20	27	45	50	80.5	85.0
2-ICGV86744	25	27	49	57	83.5	83.0
3-ICGV93255	24	25	51	56	80.0	81.0
4-ICGV89171	25	30	50	48	82.0	82.5
5-Soderi	30	29	51	55	85.0	85.5
6-Gibiesh	26	30	47	58	84.5	84.0
Mean	25	28	48.8	54	82.6	83.5
SE ±	0.94**	0.94**	1.4**	1.4**	0.64*	0.64*
C.V	11.5	11.5	11.5	11.5	3.0	3.0
Interaction	25	28	48.5	54	82.1	84.0

Appendix (13): Dry matter accumulation (gm) per plant at 30, 60 and 90 days after planting at Elobeid season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.91	6.99	13.33	1.14	11.31	19.08
2-ICGV86744	0.89	9.57	11.71	1.03	8.31	14.03
3-ICGV93255	0.71	5.49	13.21	0.82	5.38	14.17
4-ICGV89171	0.64	5.55	12.55	1.07	10.85	17.44
5-Soderi	0.68	7.18	9.31	0.88	7.59	14.31
6-Gibiesh	0.83	4.85	15.83	0.91	8.87	16.97
Mean	0.78	6.61	12.66	0.98	8.72	16.0
SE ±	0.08^{ns}	0.66**	1.1^{ns}	0.08^{ns}	0.66**	1.1^{ns}
C.V	37.4	34.5	29.8	37.4	34.5	29.8

Appendix (14): Dry matter accumulation (gm) per plant at 30, 60 and 90 days after planting at Elobeid season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	2.28	18.52	35.69	2.16	27.38	40.60
2-ICGV86744	2.40	19.75	26.04	2.38	24.75	35.35
3-ICGV93255	2.29	16.39	17.44	2.31	19.86	23.63
4-ICGV89171	2.28	18.48	35.17	3.01	25.81	33.90
5-Soderi	2.36	19.86	28.68	2.06	25.47	38.04
6-Gibiesh	2.57	18.38	23.86	2.55	19.90	33.52
Mean	2.36	18.56	27.81	2.41	23.86	34.17
SE ±	0.16^{ns}	1.3*	2.0**	0.16^{ns}	1.3*	2.0**
C.V	26.5	23.6	25.3	26.5	23.6	25.3

Appendix (15): Dry matter accumulation (gm) per plant at 30, 60 and 90 days after planting at faris season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.71	4.55	10.03	0.76	5.94	10.88
2-ICGV86744	0.58	5.03	11.25	0.56	6.25	13.65
3-ICGV93255	0.63	4.78	14.65	0.68	4.84	12.63
4-ICGV89171	0.75	5.92	13.34	0.49	6.11	17.19
5-Soderi	0.55	3.78	8.66	0.74	6.57	10.57
6-Gibiesh	0.59	3.28	8.27	0.67	6.96	11.98
Mean	0.64	4.56	11.03	0.65	6.11	12.82
SE ±	0.05^{ns}	0.51^{ns}	1.0^{ns}	0.05^{ns}	0.51^{ns}	1.0^{ns}
C.V	29.0	37.9	33.5	29.0	37.9	33.5

Appendix (16): Dry matter accumulation (gm) per plant at 30, 60 and 90 days after planting at faris season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	3.15	21.81	33.34	4.5	49.6	46.0
2-ICGV86744	3.83	17.75	26.95	5.0	43.7	52.6
3-ICGV93255	3.55	14.69	24.85	5.4	43.2	51.4
4-ICGV89171	4.51	16.40	25.85	5.3	45.3	49.5
5-Soderi	3.95	17.81	32.24	5.3	42.2	52.5
6-Gibiesh	3.35	20.31	39.57	4.9	37.6	54.5
Mean	3.72	18.13	30.47	5.07	43.6	51.08
SE ±	0.41^{ns}	1.24^{ns}	0.90^{ns}	0.41^{ns}	1.24^{ns}	0.90^{ns}
C.V	31.7	11.3	7.1	31.7	11.3	7.1

Appendix (17): Dry matter distribution % at 30 days after planting at Elobeid season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	roots	shoots	leaves	roots	shoots	leaves
1-ICGV92121	7.8	34.1	56.0	5.5	42.8	51.6
2-ICGV86744	6.9	40.3	52.5	5.8	34.4	55.3
3-ICGV93255	8.5	38.0	51.9	9.1	42.2	48.9
4-ICGV89171	9.8	38.0	52.0	6.7	38.7	50.3
5-Soderi	10.4	39.0	50.7	9.4	35.0	53.0
6-Gibiesh	6.7	40.0	53.1	7.8	37.3	55.0
Mean	8.4	38.2	52.7	7.4	38.4	52.4
SE ±	0.63^{ns}	1.68^{ns}	1.43^{ns}	0.63^{ns}	1.68^{ns}	1.43^{ns}
C.V	29.0	17.6	10.8	29.0	17.6	10.8

Appendix (18): Dry matter distribution % at 30 days after planting at Elobeid season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	roots	shoots	leaves	roots	shoots	leaves
1-ICGV92121	5.4	45.4	43.3	6.5	43.0	50.2
2-ICGV86744	5.5	41.3	53.1	5.9	39.8	56.1
3-ICGV93255	4.9	34.5	59.7	5.0	39.8	55.1
4-ICGV89171	6.1	42.0	51.8	7.1	40.5	52.4
5-Soderi	4.6	43.1	54.9	5.1	43.0	51.7
6-Gibiesh	5.5	41.3	53.2	6.4	43.8	50.0
Mean	5.3	41.3	52.7	6.0	41.7	52.6
SE ±	0.31^{ns}	1.2^{ns}	1.22^{ns}	0.31^{ns}	1.2^{ns}	1.22^{ns}
C.V	21.9	11.2	9.2	21.9	11.2	9.2

Appendix (19): Dry matter distribution % at 30 days after planting at Faris season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	roots	shoots	leaves	roots	shoots	leaves
1-ICGV92121	9.4	36.6	53.9	8.8	39.9	51.7
2-ICGV86744	8.4	40.2	51.3	8.5	36.5	55.1
3-ICGV93255	6.7	33.4	60.0	8.6	38.0	54.1
4-ICGV89171	10.6	36.4	54.2	11.9	38.0	48.0
5-Soderi	8.0	40.1	50.7	7.5	35.7	57.3
6-Gibiesh	8.0	38.2	53.7	8.1	38.2	53.6
Mean	8.5	37.5	54.0	8.9	37.7	53.3
SE ±	0.56^{ns}	1.22^{ns}	1.25^{ns}	0.56^{ns}	1.22^{ns}	1.25^{ns}
C.V	25.8	13.1	9.3	25.8	13.1	9.3

Appendix (20): Dry matter distribution % at 30 days after planting at Faris season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	roots	shoots	leaves	roots	shoots	leaves
1-ICGV92121	5.5	42.0	50.8	4.5	49.6	46.0
2-ICGV86744	5.0	40.2	49.8	5.0	43.7	52.6
3-ICGV93255	6.1	49.2	50.7	5.4	43.2	51.4
4-ICGV89171	5.3	43.3	51.7	5.3	45.3	49.5
5-Soderi	4.8	43.5	51.9	5.3	42.2	52.5
6-Gibiesh	5.1	44.0	51.0	4.9	37.6	54.5
Mean	5.3	43.7	51.0	5.0	43.6	51.1
SE ±	0.41^{ns}	1.24^{ns}	0.90^{ns}	0.41^{ns}	1.24^{ns}	0.90^{ns}
C.V	31.7	11.3	7.1	31.7	11.3	7.1

Appendix (21): Dry matter distribution % at 60 days after planting at Elobeid season 2011

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	2.3	40.6	47.0	10.4	3.3	39.8	43.4	13.5
2-ICGV86744	2.4	39.1	40.5	19.7	3.2	35.1	40.6	21.2
3-ICGV93255	3.6	38.9	46.8	11.0	3.2	38.0	48.3	10.0
4-ICGV89171	4.8	34.3	45.5	15.9	3.0	29.6	37.8	30.1
5-Soderi	3.9	34.1	39.0	22.5	2.1	30.3	49.5	17.1
6-Gibiesh	3.6	36.3	46.2	10.2	2.8	40.0	42.6	14.7
Mean	3.4	37.2	44.2	15.0	2.9	35.5	43.7	17.8
SE ±	0.34^{ns}	1.55^{ns}	1.64^{ns}	2.37^{ns}	0.34^{ns}	1.55^{ns}	1.64^{ns}	2.37^{ns}
C.V	42.7	17.0	15.0	58.0	42.7	17.0	15.0	58.0

Appendix (22): Dry matter distribution % at 60 days after planting at Elobeid season 2012

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	1.8	25.9	39.2	33.2	1.9	30.8	39.3	31.3
2-ICGV86744	1.8	30.3	43.4	25.6	1.6	29.3	40.6	28.6
3-ICGV93255	1.7	28.9	42.2	27.3	1.5	29.2	39.2	30.1
4-ICGV89171	2.4	29.0	42.9	25.6	2.0	30.7	43.2	24.2
5-Soderi	2.2	31.0	44.3	22.6	1.9	29.1	39.8	29.5
6-Gibiesh	1.7	29.2	42.1	27.0	1.6	29.1	38.6	30.7
Mean	1.9	29.1	42.4	26.9	1.8	29.7	40.1	29.1
SE ±	0.11^{ns}	0.66^{ns}	0.68*	1.08*	0.11^{ns}	0.66^{ns}	0.68*	1.08*
C.V	23.5	9.0	6.7	15.5	23.5	9.0	6.7	15.5

Appendix (23): Dry matter distribution % at 60 days after planting at Faris season 2011

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	3.9	32.6	47.0	20.7	3.1	27.1	42.0	27.7
2-ICGV86744	3.4	31.1	46.8	18.6	2.7	32.1	45.7	19.7
3-ICGV93255	2.9	29.1	54.5	13.3	3.2	32.9	44.9	18.7
4-ICGV89171	3.0	31.0	54.1	10.9	2.9	29.8	46.8	20.7
5-Soderi	4.1	37.1	48.9	10.0	2.2	30.3	45.6	22.3
6-Gibiesh	4.6	34.9	50.7	7.1	2.5	33.0	48.1	16.6
Mean	3.7	32.6	50.3	13.4	2.8	30.9	45.5	21.0
SE ±	0.25^{ns}	0.94^{ns}	1.22*	1.42**	0.25^{ns}	0.94^{ns}	1.22*	1.42**
C.V	31.5	11.8	10.2	33.0	31.5	11.8	10.2	33.0

Appendix (24): Dry matter distribution % at 60 days after planting at Faris season 2012

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	1.7	26.2	37.6	31.7	3.0	26.5	38.5	31.9
2-ICGV86744	2.5	26.0	40.9	30.8	2.3	23.2	36.5	35.4
3-ICGV93255	2.7	29.1	42.5	25.7	2.4	29.1	40.5	27.8
4-ICGV89171	2.6	26.6	45.0	25.1	2.1	27.4	40.9	29.5
5-Soderi	3.0	27.1	42.8	27.1	1.9	29.2	40.2	28.8
6-Gibiesh	2.5	29.9	41.2	26.4	2.1	27.7	40.4	29.7
Mean	2.5	27.5	41.7	27.8	2.3	27.2	39.5	30.5
SE ±	0.18^{ns}	0.83^{ns}	1.05^{ns}	1.48^{ns}	0.18^{ns}	0.83^{ns}	1.05^{ns}	1.48^{ns}
C.V	29.9	12.2	10.3	20.3	29.9	12.2	10.3	20.3

Appendix (25): Dry matter distribution % at 90 days after planting at Elobeid season 2011

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	2.6	26.5	33.5	37.4	1.9	35.0	37.0	26.1
2-ICGV86744	2.8	28.6	30.8	37.9	2.1	27.8	34.5	35.6
3-ICGV93255	2.3	29.2	27.4	41.2	2.3	26.5	29.3	42.2
4-ICGV89171	2.3	23.0	30.2	44.6	1.8	27.4	33.1	37.8
5-Soderi	3.1	25.4	31.7	40.0	2.4	30.4	33.1	34.1
6-Gibiesh	2.3	24.0	28.8	45.0	2.2	24.6	31.2	35.3
Mean	2.6	26.1	30.4	41.0	2.1	28.6	33.0	35.2
SE ±	0.16^{ns}	1.24^{ns}	1.47^{ns}	2.41^{ns}	0.16^{ns}	1.24^{ns}	1.47^{ns}	2.41^{ns}
C.V	27.6	18.2	18.6	25.3	27.6	18.2	18.6	25.3

Appendix (26): Dry matter distribution % at 90 days after planting at Elobeid season 2012

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	7.6	18.4	25.5	48.6	8.5	18.3	26.2	47.1
2-ICGV86744	8.3	21.9	29.2	40.6	7.0	21.0	27.7	44.0
3-ICGV93255	7.8	22.1	30.1	40.1	9.1	23.0	29.2	38.8
4-ICGV89171	7.0	26.8	33.1	33.1	9.9	20.0	27.7	42.4
5-Soderi	8.1	21.8	31.1	39.1	12.9	22.2	27.0	38.0
6-Gibiesh	10.6	20.7	28.6	40.2	9.7	20.9	27.1	42.2
Mean	8.2	22.0	29.6	40.3	9.5	20.9	27.5	42.1
SE ±	1.0^{ns}	0.68**	0.81^{ns}	1.41*	1.0^{ns}	0.68**	0.81^{ns}	1.41*
C.V	24.0	12.6	11.3	13.7	24.0	12.6	11.3	13.7

Appendix (27): Dry matter distribution % at 90 days after planting at Faris season 2011

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	2.0	20.5	29.0	48.5	2.1	24.4	29.7	46.4
2-ICGV86744	1.9	21.7	28.1	48.0	1.8	24.0	28.7	45.4
3-ICGV93255	2.2	21.2	26.3	51.2	2.4	22.0	30.4	45.2
4-ICGV89171	2.0	25.1	33.0	40.4	1.5	22.5	29.3	38.3
5-Soderi	2.2	24.5	29.0	48.9	1.7	23.0	27.3	48.2
6-Gibiesh	2.7	30.1	38.5	38.3	2.1	20.3	24.4	53.4
Mean	2.2	23.9	30.7	45.9	1.9	22.7	28.3	38.6
SE ±	0.12^{ns}	1.09^{ns}	1.4^{ns}	1.75^{ns}	0.12^{ns}	1.09^{ns}	1.4^{ns}	1.75^{ns}
C.V	23.4	18.9	18.9	15.2	23.4	18.9	18.9	15.2

Appendix (28): Dry matter distribution % at 90 days after planting at Faris season 2012

Genotypes	Without NPK treatment				With NPK treatment			
	roots	shoots	leaves	Pods	roots	shoots	leaves	Pods
1-ICGV92121	1.2	22.5	31.5	44.7	1.3	26.2	31.8	40.8
2-ICGV86744	1.6	26.3	31.8	39.8	1.3	27.5	32.1	39.7
3-ICGV93255	1.8	29.1	31.7	39.8	1.4	28.9	34.3	47.0
4-ICGV89171	2.4	28.9	34.2	35.3	1.2	22.6	31.7	44.5
5-Soderi	1.5	25.0	31.6	41.9	1.0	26.7	30.3	42.4
6-Gibiesh	1.1	20.6	28.8	41.6	1.2	26.3	30.8	41.8
Mean	1.6	25.4	31.6	40.5	1.2	26.4	31.8	42.7
SE ±	0.18^{ns}	1.20^{ns}	1.54^{ns}	1.92^{ns}	0.18^{ns}	1.20^{ns}	1.54^{ns}	1.92^{ns}
C.V	23.6	18.6	19.6	18.5	23.6	18.6	19.6	18.5

Appendix (29): Leaf area (cm^2) per plant at 30, 60 and 90 days after planting at Elobeid season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	116.0	642.5	1041.2	163.0	989.2	2519.0
2-ICGV86744	120.4	920.4	540.7	149.0	1071.8	1026.9
3-ICGV93255	85.5	648.1	1567.7	100.2	858.7	1063.2
4-ICGV89171	81.6	615.9	621.5	117.2	1342.4	788.4
5-Soderi	77.6	717.4	605.3	114.1	822.1	1131.8
6-Gibiesh	114.0	636.8	995.7	120.6	1430.0	888.6
Mean	99.2	696.9	895.4	127.4	1085.7	1236.3
SE ±	10.5^{ns}	149.0^{ns}	133.6**	10.5^{ns}	149.0^{ns}	133.6**
C.V	37.1	66.9	50.1	37.1	66.9	50.1

Appendix (30): Leaf area (cm^2) per plant at 30, 60 and 90 days after planting at Elobeid season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	212.9	1256.4	2110.0	238.3	1668.9	1293.4
2-ICGV86744	272.0	1390.6	12053.2	369.3	1804.6	1410.5
3-ICGV93255	401.0	1141.9	834.8	107.5	1468.2	1208.1
4-ICGV89171	335.9	1435.5	2029.7	241.9	2158.3	1669.7
5-Soderi	170.3	1268.4	1705.6	151.4	1601.2	1506.9
6-Gibiesh	222.3	1344.7	1296.2	128.9	1479.0	1711.3
Mean	269.1	1306.3	2781.9	206.2	1696.7	1466.7
SE ±	51.9^{ns}	117.5^{ns}	108.1**	51.9^{ns}	117.5^{ns}	108.1**
C.V	87.4	31.3	28.8	87.4	31.3	28.8

Appendix (31): Leaf area (cm^2) per plant at 30, 60 and 90 days after planting at Faris season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	65.1	258.3	347.9	86.6	345.9	425.7
2-ICGV86744	51.4	305.3	656.3	62.7	436.0	819.4
3-ICGV93255	66.8	360.1	478.6	63.7	265.3	509.2
4-ICGV89171	69.4	447.5	430.9	44.4	404.5	603.0
5-Soderi	42.9	247.2	320.2	87.9	431.7	396.8
6-Gibiesh	48.6	200.5	437.9	65.0	457.1	461.3
Mean	57.4	303.2	445.3	68.4	390.1	535.9
SE ±	5.8^{ns}	40.5^{ns}	47.6*	5.8^{ns}	40.5^{ns}	47.6*
C.V	36.7	46.7	38.8	36.7	46.7	38.8

Appendix (32):Leaf area (cm^2) per plant at 30, 60 and 90 days after planting at Faris season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	296.9	1318.4	1962.9	574.1	976.4	2042.3
2-ICGV86744	326.7	1109.6	794.9	521.9	1171.0	1506.5
3-ICGV93255	441.5	824.9	1052.9	326.9	1067.1	1151.6
4-ICGV89171	626.7	1013.0	1306.7	496.3	1210.1	1532.1
5-Soderi	329.8	834.4	1530.5	499.8	1147.7	2372.7
6-Gibiesh	368.4	1172.6	1297.1	545.4	1560.0	1902.2
Mean	398.3	1045.5	1324.2	494.1	1188.7	1751.2
SE ±	60.8^{ns}	83.9^{ns}	143.9**	60.8^{ns}	83.9^{ns}	143.9**
C.V	54.5	30.0	37.4	54.5	30.0	37.4

Appendix (33): Number of nodules per plant at Elobeid at 60 and 90 days after plant

Genotypes	2011				2012			
	Without NPK treatment		With NPK treatment		Without NPK treatment		With NPK treatment	
	60	90	60	90	60	90	60	90
1-ICGV92121	10.5	24.0	24.0	10.9	25.8	16.5	25.9	12.9
2-ICGV86744	10.0	15.3	15.3	10.5	23.3	10.3	25.6	14.4
3-ICGV93255	9.5	13.9	13.9	7.5	24.5	6.8	35.3	5.5
4-ICGV89171	15.4	14.1	14.1	7.4	29.0	8.1	29.6	9.4
5-Soderi	14.5	14.6	14.6	11.5	28.0	16.3	37.5	10.9
6-Gibiesh	19.5	16.0	16.0	12.6	29.8	12.6	32.3	10.0
Mean	13.2	16.3	16.3	10.1	26.7	11.8	31.0	10.5
SE ±	1.6^{ns}	1.1^{ns}	1.6^{ns}	1.1^{ns}	2.33^{ns}	0.86**	2.33^{ns}	0.86**
C.V	42.0	43.9	42.0	43.9	32.3	31.0	32.3	31.0

Appendix (34): Number of nodules per plant at Faris at 60 and 90 days after plant

Genotypes	2011				2012			
	Without NPK treatment		With NPK treatment		Without NPK treatment		With NPK treatment	
	60	90	60	90	60	90	60	90
1-ICGV92121	4.8	16.0	6.3	11.5	23.1	14.9	29.3	10.1
2-ICGV86744	5.5	11.0	8.0	12.0	29.3	6.0	36.3	10.4
3-ICGV93255	5.5	12.3	6.9	13.3	24.4	7.6	32.8	11.3
4-ICGV89171	7.0	20.0	8.8	11.8	26.3	9.1	34.6	6.3
5-Soderi	5.0	7.0	4.5	5.5	28.3	12.6	28.8	8.8
6-Gibiesh	6.0	15.5	11.3	13.0	26.1	12.5	43.6	11.8
Mean	5.6	13.6	6.0	11.2	26.3	10.5	34.2	9.8
SE ±	0.97^{ns}	2.15^{ns}	0.97^{ns}	2.15^{ns}	1.86*	0.67**	1.86*	0.67**
C.V	58.9	69.6	58.9	69.6	24.7	26.5	24.7	26.5

Appendix (35): Crop growth rate (g/day/plant) at Elobeid Station Farm at 30, 60 and 90 days after plant season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.030	0.202	0.214	0.038	0.339	0.259
2-ICGV86744	0.029	0.289	0.125	0.034	0.217	0.182
3-ICGV9325 5	0.024	0.159	0.258	0.027	0.152	0.302
4-ICGV89171	0.021	0.164	0.167	0.036	0.326	0.220
5-Soderi	0.022	0.217	0.086	0.030	0.224	0.224
6-Gibiesh	0.028	0.134	0.353	0.030	0.265	0.270
Mean	0.026	0.194	0.201	0.033	0.254	0.243
SE ±	0.01^{ns}	0.022*	0.034^{ns}	0.01^{ns}	0.022*	0.034^{ns}
C.V	37.5	40.9	62.3	37.5	40.9	62.3

Appendix (36): Crop growth rate (g/day/plant) at Elobeid Station Farm at 30, 60 and 90 days after plant season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.024	0.128	0.182	0.025	0.172	0.165
2-ICGV86744	0.019	0.149	0.208	0.019	0.189	0.249
3-ICGV93255	0.021	0.138	0.329	0.023	0.139	0.261
4-ICGV89171	0.025	0.172	0.174	0.016	0.187	0.369
5-Soderi	0.019	0.108	0.168	0.025	0.205	0.133
6-Gibiesh	0.020	0.090	0.171	0.022	0.210	0.186
Mean	21.3	0.131	0.175	0.022	0.184	0.227
SE ±	0.001^{ns}	0.017^{ns}	0.033^{ns}	0.001^{ns}	0.017^{ns}	0.033^{ns}
C.V	28.8	43.1	61.0	28.8	43.1	61.0

Appendix (37): Crop growth rate (g/day/plant) at Faris Station Farm at 30, 60 and 90 days after plant season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.076	0.542	0.570	0.072	0.843	0.468
2-ICGV86744	0.080	0.580	0.210	0.079	0.745	0.353
3-ICGV93255	0.076	0.573	0.107	0.077	0.588	0.137
4-ICGV89171	0.076	0.540	0.555	0.100	0.760	0.270
5-Soderi	0.079	0.583	0.303	0.069	0.783	0.452
6-Gibiesh	0.084	0.528	0.183	0.080	0.414	0.453
Mean	0.079	0.558	0.321	0.080	0.689	0.356
SE ±	0.002^{ns}	0.046*	0.067^{ns}	0.002^{ns}	0.046*	0.067^{ns}
C.V	26.4	30.11	79.4	26.4	30.11	79.4

Appendix (38): Crop growth rate at (g/day/plant) Faris Station Farm at 30, 60 and 90 days after plant season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.105	0.500	0.385	0.208	0.403	0.903
2-ICGV86744	0.127	0.430	0.306	0.125	0.635	0.377
3-ICGV93255	0.118	0.370	0.340	0.117	0.500	0.479
4-ICGV89171	0.150	0.405	0.338	0.180	0.415	0.821
5-Soderi	0.133	0.462	0.481	0.155	0.972	0.850
6-Gibiesh	0.112	0.565	0.642	0.120	0.782	0.665
Mean	0.124	0.455	0.414	0.151	0.618	0.683
SE ±	0.007^{**}	0.061*	0.12^{ns}	0.007^{**}	0.061*	0.12^{ns}
C.V	22.6	46.1	84.4	22.6	46.1	84.4

Appendix (39): Specific Leaf area at Elobeid Station Farm at 30, 60 and 90 days after plant season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	258.4	469.2	358.0	291.4	469.7	451.0
2-ICGV86744	274.6	449.1	251.7	288.6	543.9	396.4
3-ICGV93255	250.4	570.8	626.7	234.9	622.3	560.6
4-ICGV89171	253.2	492.8	337.5	218.7	481.4	356.4
5-Soderi	233.3	445.7	344.1	263.3	603.3	395.9
6-Gibiesh	268.9	518.8	353.4	269.4	588.4	422.1
Mean	256.5	491.1	378.6	261.1	551.5	430.4
SE ±	16.8^{ns}	47.8^{ns}	35.0*	16.8^{ns}	47.8^{ns}	35.0*
C.V	14.3	36.7	34.6	14.3	36.7	34.6

Appendix (40): Specific Leaf area at Elobeid Station Farm at 30, 60 and 90 days after plant season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	174.5	173.8	123.7	217.1	205.4	141.9
2-ICGV86744	174.2	182.4	201.5	200.7	201.9	204.1
3-ICGV93255	173.0	275.0	125.9	176.4	180.9	134.7
4-ICGV89171	167.8	218.4	101.4	175.4	211.3	124.7
5-Soderi	155.8	154.6	117.5	215.3	209.3	134.5
6-Gibiesh	146.7	167.3	142.6	172.5	198.0	167.9
Mean	165.3	195.3	135.4	192.9	201.1	151.3
SE ±	9.8^{ns}	13.3^{ns}	11.4^{ns}	9.8^{ns}	13.3^{ns}	11.4^{ns}
C.V	21.9	26.9	31.7	21.9	26.9	31.7

Appendix (41): Specific Leaf area at Faris at 30, 60 and 90 days after plant season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	129.5	172.9	217.6	90.1	153.7	127.4
2-ICGV86744	142.0	162.0	159.3	112.3	183.6	162.2
3-ICGV93255	231.3	166.7	123.3	64.2	190.5	131.5
4-ICGV89171	132.7	172.0	319.4	93.1	193.0	119.8
5-Soderi	77.2	144.5	185.2	73.3	160.0	111.0
6-Gibiesh	148.0	175.2	136.6	75.8	191.8	130.1
Mean	143.5	165.6	190.2	84.8	178.8	130.3
SE ±	20^{ns}	7.2^{ns}	19.3**	20^{ns}	7.2^{ns}	19.3**
C.V	70.0	16.8	48.0	70.0	16.8	48.0

Appendix (42): Specific Leaf area at Faris at 30, 60 and 90 days after plant season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	185.1	148.9	193.9	206.4	140.0	156.1
2-ICGV86744	173.8	148.6	106.0	271.3	136.4	137.2
3-ICGV93255	220.1	123.9	127.2	176.6	140.8	119.7
4-ICGV89171	267.2	133.3	153.3	166.6	130.1	108.5
5-Soderi	232.0	122.3	143.6	216.6	118.7	166.3
6-Gibiesh	214.0	141.4	133.9	262.8	144.6	129.6
Mean	215.4	136.4	143.0	216.7	135.1	136.2
SE ±	25.1^{ns}	6.3^{ns}	17.3^{ns}	25.1^{ns}	6.3^{ns}	17.3^{ns}
C.V	46.4	18.5	30.6	46.4	18.5	30.6

Appendix (43): Net assimilation rate (g/dm^2/day) of groundnut genotypes and treatments at 30, 60 and 90 days after planting at Elobeid season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.00054	0.00029	0.00027	0.00051	0.00032	0.00037
2-ICGV86744	0.00051	0.00035	0.00024	0.00050	0.00029	0.00035
3-ICGV93255	0.00052	0.00033	0.00021	0.00056	0.00022	0.00033
4-ICGV89171	0.00052	0.00030	0.00023	0.00070	0.00035	0.00015
5-Soderi	0.00055	0.00033	0.00025	0.00052	0.00029	0.00012
6-Gibiesh	0.00051	0.00021	0.00024	0.00052	0.00022	0.00029
Mean	0.00053	0.00030	0.00024	0.00055	0.00028	0.00027
SE ±	0.002*	0.0013*	0.011*	0.002*	0.0013*	0.011*
C.V	23.8	23.7	18.7	23.8	23.7	18.7

Appendix (44): Net assimilation rate ($g/dm^2/day$) of groundnut genotypes and treatments at 30, 60 and 90 days after planting at Elobeid season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.00056	0.00016	0.00025	0.00027	0.00020	0.00013
2-ICGV86744	0.00040	0.00017	0.00012	0.00049	0.00013	0.00020
3-ICGV93255	0.00042	0.00013	0.00011	0.00039	0.00016	0.00017
4-ICGV89171	0.00055	0.00013	0.00020	0.00071	0.00017	0.00016
5-Soderi	0.00030	0.00022	0.00023	0.00061	0.00025	0.00015
6-Gibiesh	0.00064	0.00018	0.00013	0.00055	0.00020	0.00015
Mean	0.00048	0.00017	0.00017	0.00050	0.00019	0.00016
SE ±	0.017^{ns}	0.0013^{ns}	0.0013^{ns}	0.017^{ns}	0.0013^{ns}	0.0013^{ns}
C.V	30.7	17.3	13.6	30.7	17.3	13.6

Appendix (45): Net assimilation rate ($g/dm^2/day$) of groundnut genotypes and treatments at 30, 60 and 90 days after planting at Faris season 2011

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.00036	0.00013	0.00023	0.00030	0.00021	0.00012
2-ICGV86744	0.00034	0.00015	0.00020	0.00030	0.00014	0.00021
3-ICGV93255	0.00035	0.00014	0.00025	0.00034	0.00013	0.00022
4-ICGV89171	0.00036	0.00016	0.00025	0.00032	0.00015	0.00020
5-Soderi	0.00035	0.00015	0.00020	0.00032	0.00011	0.00011
6-Gibiesh	0.00040	0.00013	0.00012	0.00036	0.00014	0.00010
Mean	0.00036	0.00014	0.00021	0.00032	0.00015	0.00016
SE ±	0.021^{ns}	0.001*	0.017*	0.021^{ns}	0.001*	0.017*
C.V	29.3	34.1	42.2	29.3	34.1	42.2

Appendix (46): Net assimilation rate ($g/dm^2/day$) of groundnut genotypes and treatments at 30, 60 and 90 days after planting at Faris season 2012

Genotypes	Without NPK treatment			With NPK treatment		
	30 days	60 days	90 days	30 days	60 days	90 days
1-ICGV92121	0.00040	0.00014	0.00017	0.00044	0.00014	0.00016
2-ICGV86744	0.00051	0.00016	0.00017	0.00036	0.00018	0.00016
3-ICGV93255	0.00054	0.00013	0.00018	0.00054	0.00015	0.00016
4-ICGV89171	0.00039	0.00014	0.00011	0.00051	0.00016	0.00012
5-Soderi	0.00056	0.00013	0.00021	0.00047	0.00016	0.00021
6-Gibiesh	0.00051	0.00022	0.00017	0.00034	0.00022	0.00020
Mean	0.00049	0.00015	0.00017	0.00044	0.00017	0.00017
SE ±	0.024*	0.022^{ns}	0.027^{ns}	0.024*	0.022^{ns}	0.027^{ns}
C.V	31.7	21.9	17.4	31.7	21.9	17.4

Appendix (47): Correlations between physiological traits and hay and pod yield at Elobeid season 2011

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.307*					
CGR	0.117**	0.697**				
LAI	1.00**	0.308*	0.117^{ns}			
SLA	0.128^{ns}	-0.131^{ns}	0.077^{ns}	0.125^{ns}		
Pod yield	0.005^{ns}	0.087^{ns}	-0.118^{ns}	0.007^{ns}	-0.446^{ns}	
Hay yield	0.197^{ns}	0.116^{ns}	-0.182^{ns}	0.199^{ns}	-0.168^{ns}	0.030^{ns}

Appendix (48): Correlations between physiological traits and hay and pod yield at Elobeid season 2012

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.453**					
CGR	0.259^{ns}	0.798**				
LAI	0.985**	0.501**	0.290*			
SLA	0.526**	0.231^{ns}	0.199^{ns}	0.512**		
Pod yield	-0.10^{ns}	-0.169^{ns}	-0.212^{ns}	-0.104^{ns}	0.146^{ns}	
Hay yield	-0.09^{ns}	-0.093^{ns}	-0.152^{ns}	-0.077^{ns}	0.115^{ns}	0.825**

Appendix (49): Correlations between physiological traits and hay and pod yield at Faris season 2011

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.601**					
CGR	0.500**	0.826**				
LAI	0.100**	0.601**	0.500**			
SLA	0.664**	-0.046^{ns}	-0.048^{ns}	0.664**		
Pod yield	0.148^{ns}	-0.014^{ns}	0.17^{ns}	0.148^{ns}	0.275*	
Hay yield	-0.19^{ns}	-0.277^{ns}	-0.142^{ns}	-0.191^{ns}	0.023^{ns}	-0.078^{ns}

Appendix (50): Correlations between physiological traits and hay and pod yield at Faris season 2012

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.731**					
CGR	0.572**	0.891**				
LAI	0.996**	0.724**	0.572**			
SLA	0.481**	-0.103^{ns}	-0.137^{ns}	0.475**		
Pod yield	0.050^{ns}	0.194^{ns}	0.032^{ns}	0.039^{ns}	-0.117^{ns}	
Hay yield	0.083^{ns}	0.224^{ns}	0.044^{ns}	0.078^{ns}	-0.193^{ns}	0.955**

Appendix (51): Correlations between physiological traits and hay and pod yield without NPK treatment at Elobeid season 2011

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.134^{ns}					
CGR	-0.02^{ns}	0.605**				
LAI	1.00**	0.134^{ns}	-0.022^{ns}			
SLA	0.025^{ns}	-0.083^{ns}	0.186^{ns}	0.026^{ns}		
Pod yield	0.053^{ns}	0.181^{ns}	0.018^{ns}	0.053^{ns}	-0.508^{ns}	
Hay yield	0.380^{ns}	0.034^{ns}	-0.177^{ns}	0.380^{ns}	-0.031^{ns}	-0.194^{ns}

Appendix (52): Correlations between physiological traits and hay and pod yield with NPK treatment at Elobeid season 2011

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.448**					
CGR	0.296^{ns}	0.806**				
LAI	1.00**	0.448**	0.296^{ns}			
SLA	0.276^{ns}	-0.29^{ns}	-0.68^{ns}	0.267^{ns}		
Pod yield	-0.11^{ns}	0.041^{ns}	-0.284^{ns}	-0.109^{ns}	-0.365^{ns}	
Hay yield	-0.20^{ns}	0.036^{ns}	-0.207^{ns}	-0.197^{ns}	-0.593^{ns}	0.290^{ns}

Appendix (53): Correlations between physiological traits and hay and pod yield without NPK treatment at Elobeid season 2012

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.646**					
CGR	0.424**	0.739**				
LAI	1.00**	0.646**	0.425*			
SLA	0.611**	0.336^{ns}	0.317^{ns}	0.611**		
Pod yield	0.093^{ns}	-0.29^{ns}	-0.304^{ns}	-0.094^{ns}	0.168^{ns}	
Hay yield	0.054^{ns}	-0.101^{ns}	-0.172^{ns}	0.054^{ns}	0.182^{ns}	0.864**

Appendix (54): Correlations between physiological traits and hay and pod yield with NPK treatment at Elobeid season 2012

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.218^{ns}					
CGR	0.064^{ns}	0.854**				
LAI	0.963**	0.327^{ns}	0.135^{ns}			
SLA	0.519**	0.058^{ns}	-0.038^{ns}	0.519**		
Pod yield	-0.11^{ns}	-0.036^{ns}	-0.114^{ns}	-0.122^{ns}	0.284^{ns}	
Hay yield	-0.30^{ns}	-0.081^{ns}	-0.127^{ns}	-0.260^{ns}	0.191^{ns}	0.781**

Appendix (55): Correlations between physiological traits and hay and pod yield without NPK treatment at Faris season 2011

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.615**					
CGR	0.563**	0.913**				
LAI	1.00**	0.615**	0.563**			
SLA	0.609**	-0.041^{ns}	-0.155^{ns}	0.609**		
Pod yield	-0.11^{ns}	-0.336^{ns}	-0.466^{ns}	-0.155^{ns}	0.170^{ns}	
Hay yield	-0.13^{ns}	-0.220^{ns}	-0.326^{ns}	-0.131^{ns}	-0.020^{ns}	0.307^{ns}

Appendix (56): Correlations between physiological traits and hay and pod yield with NPK treatment at Faris season 2011

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.562**					
CGR	0.417*	0.746**				
LAI	1.00**	0.562**	0.417**			
SLA	0.697**	-0.109^{ns}	-0.036^{ns}	0.697**		
Pod yield	0.470**	0.284^{ns}	0.221^{ns}	0.471**	0.380^{ns}	
Hay yield	-0,172^{ns}	-0.275^{ns}	0.031^{ns}	-0.173^{ns}	0.117^{ns}	0.300^{ns}

Appendix (57): Correlations between physiological traits and hay and pod yield without NPK treatment at Faris season 2012

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.769**					
CGR	0.636**	0.936**				
LAI	1.00**	0.769**	0.636**			
SLA	0.506**	0.032^{ns}	-0.074^{ns}	0.506**		
Pod yield	0.333^{ns}	0.403*	0.255^{ns}	0.333^{ns}	-0.096^{ns}	
Hay yield	0.348^{ns}	0.335^{ns}	0.186^{ns}	0.348^{ns}	-0.094^{ns}	0.959**

Appendix (58): Correlations between physiological traits and hay and pod yield with NPK treatment at Faris season 2012

	LA	TDM	CGR	LAI	SLA	Pod yield
LA						
TDM	0.625**					
CGR	0.516**	0.875**				
LAI	0.990**	0.612**	0.521**			
SLA	0.460*	-0.305^{ns}	-0.209^{ns}	0.446*		
Pod yield	-0.47^{ns}	-0.181^{ns}	-0.188^{ns}	-0.481^{ns}	-0.243^{ns}	
Hay yield	-0.42^{ns}	-0.071^{ns}	-0.131^{ns}	-0.428^{ns}	0.072^{ns}	0.943**