EFFECT OF DEFOLIATION ON THE GROWTH AND SEED YIELD OF FOUR GROUNDNUT (*ARACHIS HYPOGAEA* L.) CULTIVARS

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EFFECT OF DEFOLIATION ON THE GROWTH AND SEED YIELD OF FOUR GROUNDNUT (*ARACHIS HYPOGAEA* L.) CULTIVARS

BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER OF SCIENCE DEGREE IN BOTANY

DEPARTMENT OF BIOLOGICAL SCIENCES,

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AHMADU BELLO UNIVERSITY, ZARIA

NIGERIA

NOVEMBER, 2014

DECLARATION

I declare that the work in this Thesis entitled "EFFECT OF DEFOLIATION ON THE GROWTH AND SEED YIELD OF FOUR GROUNDNUT (*ARACHIS HYPOGAEA* L.) CULTIVARS" was carried out by me in the Department of Biological Sciences. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this Thesis was previously presented for another degree or diploma at this or any other Institution.

Sylvanus Umar JOSEPH _____ _____

Signature Date

CERTIFICATION

This thesis entitled: "EFFECT OF DEFOLIATION ON THE GROWTH AND SEED YIELD OF FOUR GROUNDNUT (*ARACHIS HYPOGAEA* L.) CULTIVARS" BY Sylvanus Umar JOSEPH meets the regulations governing the award of the degree of Master of Science in Botany of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

Four groundnut (*Arachis hypogaea* L.) varieties (SAMNUT 21, SAMNUT 22, SMANUT 23 and SAMNUT 24) were grown in the Botanical garden, Department of Biological Sciences, Ahmadu Bello University, Zaria to determine the effects of defoliation on the growth and yield of the varieties. The experiments were laid out in a completely randomized design with five treatments (defoliation) levels. The plants were subjected to 5 levels of defoliation: 0 (no defoliation), 25, 50, 75 and 100% at 5 weeks after planting (WAP). The plants were sampled at 4, 7 and 10 WAP for assessment of growth parameters and at harvest the yield parameters were determined. The results of this study revealed that, 75% defoliation increased plant height in most cases. The control and 25% defoliation were found to increase root nodules, shoot and root dry matter, and shoot and root relative growth rate (RGR) in most cases. The 75 and 100% defoliation levels were found to significantly reduce vegetative parameters in groundnut varieties except plant height. The control and 50% defoliation had the highest flower production but flower production decreased with increase in defoliation with 100% defoliation level being the lowest in most cases. Total pods, number of matured pods per plant, haulms weight, pod dry weight and seed weight decreased with increase in defoliation but the number of immatured pods per plant increased with increase in defoliation level. The 25 and 50% defoliation levels were found to increase pod yield and haulms weight respectively but the 100% defoliation level produced the lowest yield in most cases. The data showed that varieties SAMNUT 22 and SAMNUT 21 showed higher values in vegetative parameters and yield parameters than the other varieties. Also, SAMNUT 23 showed the lowest values in both vegetative and yield parameters. In conclusion, the impact of defoliation on both vegetative and yield varies among varieties. The 25 and 50% defoliation increased vegetative and yield

parameters in most cases but the 75 and 100% defoliation levels adversely reduced plant development and yield.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Origin and Classification of Groundnut

Groundnut (*Arachis hypogea* L.*)* belongs to Family: Fabaceae, Sub-Family: Papilionaceae, Genus: *Arachis and* Species: *hypogaea.* It originated from Latin America and was introduced into West Africa by Portuguese traders in the 16th century (Shankarappa *et al*., 2003; Olawale *et al*., 2014). The origin of this crop dates back to 350 BC (Hommones, 1994). Hommones, (1994) also reported that, the first probable domestication of groundnut took place in the valley of the Panama and Paraguay River System in the Grain Chaco area of South America and then move to the North America through slave trade.

1.2 Botanical Description

Reports showed that the cultivated groundnuts are divided into two large botanical groups: 'Virginia' and 'Spanish-Valencia', on the basis of branching pattern "alternate" and "sequential". They stated that these cultivars are group within the two branching pattern considered as subspecies. In the 'Virginia' group, the main stem does not have reproductive axes. Alternating pairs of vegetative and reproductive axes are borne on the laterals branches and on other branches. In the 'Spanish- Valencia' group, reproductive branches are borne in a series on successive nodes of the cotyledonary and other lateral branches, on which the first branch is always reproductive. Reproductive branches are also borne directly on the main axis at higher nodes (Prasad *et al*., 2010).

1.3 Requirements for Groundnut Growth

Groundnut is essentially a tropical plant and requires a long and warm growing season. The favourable climate for groundnut is a well-distributed rainfall of at least 500mm during the crop-growing season, and with abundance of sunshine and relatively warm temperature (Weiss,

2000). Weiss (2000) added that temperature in the range of 25 to 30^{o}C is optimum for plant development and warm and moist conditions are very favourable than cool and wet climate, which results in slow germination and seedling emergence, increasing the risk of seed rot and seedling diseases. Msrivani (2009) reported that, temperature is the major environmental factor that determines the rate of crop development. Temperature above 35^{0}C inhibits the growth of groundnut, adequate and well distributed rainfall during the growing season especially during flowering, pegging and pod formation stages, is essential for maximum yield and quality of groundnut (Msrivani, 2009). Groundnut requires 500 to 1600mm of rainfall, which may last for 70 to 200 days of rainy season in the Sudan Savannah. It also requires well drained light coloured loosed friable sandy loamy soil, optimum moisture in pod zone and mean daily temperature of approximately 30^{0}C.

1.4 Areas of Growth and Production Level

Misari *et al.* (1980) reported that, agro ecological zone of groundnut production are the Sahel (12^{0} to 13^{0}N), Sudan (10^{0} to 13^{0}N) and Northern half of the Guinea savannah (6^{0} to 8^{0}N). Major groundnut zones are the Sudan and the Guinea Savanna where the soil and agro climatological conditions are favourable.

The production of groundnut varies from 3,500 kg/ha in the United States of America to 2,500 kg/ha in the South America, 1,600 kg/ha in Asia, and less than 800 kg/ha in Africa. This variation is due to mainly to various abiotic and biotic constraints (Prasad *et al*., 2010). In Nigeria, cultivated area under groundnut is about 1.0 to 2.5 million hectares annually and yields ranged of 500-3000 kg/ha. The seed yield in northern Nigeria is about 3000 kg/ha (Taru *et al.*, 2008). In Nigeria, groundnut is produced in almost all the Northern States, the leading producing states include: Niger, Kano, Jigawa, Zamfara, Kebbi, Sokoto, Katsina, Kaduna,

Adamawa, Yobe, Plateau, Bauchi, Borno, Taraba, Gombe and Nassarawa (Anonymous, 2010). Commercial production of groundnut in Nigeria is concentrated in the Northern parts of the country particularly in areas between the Northern Guinea and Sudan Savanna zone (NAERLS, 2006). However, due to the high commercial value and the attendant high demand, the crop is now gaining popularity as a cash crop for peasant farmers in the southern parts of Nigeria. But unlike in Northern Nigeria where recommendations have been made for plant densities and phosphorus fertilization for guaranteed stable yields of groundnut (NAERLS, 2006), such authentic and vital information are yet to be made available in the humid parts of Nigeria where the prospect for commercial cultivation of the crop is high.

1.5 Economic Importance and Uses of Groundnut

Groundnut (*Arachis hypogaea* L.) is an important oil seed crop as its seed contains 44-56 % oil and 22-30 % protein on a dry basis (Reddy *et al.,* 2003*).* Groundnuts are used for oil extraction, food and as ingredient in confectionary products. Following the oil extraction, the residual cake is processed largely for animal feed, but it is also used for human consumption. Quality attribute that are important for end use of groundnut vary among the developed and developing countries. Groundnut also has a variety of industrial end uses, for instance; paint, varnish, lubricating oil, leather dressings, furniture polish, insecticides and nitroglycerin are made from groundnut oil. Soap is made from saponified oil and many cosmetics contain groundnut oil and its derivatives. The protein portion of the oil is used in manufacturing of some textile fibres. Groundnut shells are used in the manufacture of plastic, wallboard, abrasives, fuel, cellulose (used in rayon and paper) and mucilage (glue) (Anonymous, 2011).

National Peanut Council (NPC) (2002) stated that, groundnut is used for making margarine, candy, salted groundnut, crackers/cookies, salad oils and soaps. It was however reported that, almost every part of the groundnut plant is used in some ways. According to Idama (2000),

over 330 products can be commercially produced from groundnut and jobs can be directly created from massive groundnut production with small improvement in the technology and the use of improved variety with corresponding increase of cultivated hectares.

1.6 Problems of Groundnut Production

According to Akobundu *et al.* (1998), farmers are faced with erratic rainfall, decreasing soil fertility and inadequate supply of inputs. They added that some of the constraints that limit groundnut production include: soil degradation due to wind erosion, pest (i.e. nematodes and termites), decreasing yield, lack of availability of key inputs (seeds, fertilizer and agriculture equipment) and lack of food security. Akobundu *et al*. (1998) also stated that, the natural resources degradation, desertification, higher auto consumption levels and declining seed quality leading to lower yields. Ihejirika *et al.* (2008) carried out experiment with Groundnut variety P1274/191 to examine the effect of insects' defoliation and concluded that groundnut obtained highest damage from insect pests among other pests (Ihejirika *et al.*, 2008). The foliage beetle *Ootheca mutabilois* produces characteristic inter-veinal holes in the leaves of the young plants (NRI, 1996; Ihejirika *et al*, 2008). Insect pests are an important factor in the infliction of injury on crops (crop damage) and also they act as vectors of plant pathogens, insect pests among others cause considerable loss to groundnut farmers in Nigeria (Ihejirika *et al*, 2008). Adult beetles and larvae feed on the pods and leaves of groundnut causing numerous small holes (NRI, 1996). Leaves injuries delay plant development, photosynthetic activities and reduce yield (NRI, 1996). Groundnut sucking bug, *Rhyparochromus litotoralis* (Dist.), is one of the most important insect pests of groundnut in Northern Nigeria (Samaila and Malgwi, 2012). They added that *R. litotoralis* commonly known as Lygaeid bug, or groundnut pod sucking bugs, which belong to the order Heteroptera and family Lygaeidae is found in all groundnut areas in India and in large clusters in the North eastern part of Nigeria, where it is

known to cause serious damage to groundnut during harvest, but detailed record on history, biology and it's life cycle is lacking in Nigeria (Samaila and Malgwi, 2012). However, the closest member of the order Heteroptera to this bug based on close observation is the groundnut hopper (*Hilda patruelis*) (Heteroptera: Tettigometridae). Malgwi and Onu (2004) reported that, the detailed life history of this pest is not known, in spite of the fact that they are found in large numbers under harvested groundnuts in the field.

The production of this crop of great economic importance is facing decline in yield due to several factors of which leaves eating insects is one of the chief factor. Therefore, there is the need to evaluate the available groundnut varieties for their response to defoliation conditions.

1.7 Statement of Problem

Groundnut is one of the most popular commercial crops in Nigeria which account for 70% of the total Nigeria export earning between 1956 and 1967 but declined between 1957 and Mid-1980s due to combined effect of drought and diseases (Taru *et al*. , 2008; Samaila and Malgwi 2012; Girei *et al*., 2013). Legumes are not properly protected from insects in tropical and sub-tropical countries, therefore, leaf eating insects and diseases are common in tropical and sub-tropical countries where farmers do not protect their crops adequately (Mondal *et al.,* 2011). Adult beetles and larvae feed on the pods and leaves of legumes causing numerous small holes, this injuries delay plant development of photosynthetic activities and reduce yield (NRI, 1996).

Due to high economic value of groundnut there is the need to determine the effect of defoliation levels on some of the available groundnut varieties in the guinea savanna zone of Nigeria.

1.8 Justification

Information about the reaction of these groundnut varieties to defoliation are not well documented in literature most especially in Nigeria. This research will provide information on

the reaction of groundnut varieties to defoliation and thereby identify those resistant to defoliation.

1.9 Aim

The aim of this study is to evaluate the effect of leaf defoliation on the growth and yield of groundnut varieties.

1.10 Objectives

The objectives of this study were:

1. To determine the effect of defoliation on the vegetative growth parameters of groundnut varieties.
2. To determine the effect of defoliation on the yield parameters of groundnut varieties.

1.11 Hypotheses

1. Leaves defoliation does not have effect on the vegetative growth parameters of groundnut varieties.
2. Leaves defoliation does not have effect on yield parameters of groundnut varieties.

CHAPTER TWO

2.0 LITRATURE REVIEW

2.1 Groundnut and Defoliation

The effect of manipulation of source (leaf) size in legumes have been studied and reported advantageous and disadvantageous in Soybean, Okra, Cowpea, and Sunflower (Board and Harville, 1998; Bhatt and Rao, 2003; Hossain *et al.,* 2006; Abdi *et al.,* 2007; Barimanvandi *et al.,* 2010). Enyi (2008) conducted experiment with four legumes and concluded that, defoliation reduced dry weight of stem, pods, grains and size of individual grains in all the four legumes crops studied and dry weight of flowering inflorescence stalk in the case of cowpeas and green gram only. Enyi (2008) added that, the adverse effect is more pronounce when defoliation was complete than when half of the number of leaves were removed and when it happened during early podding stage. In groundnut, pod number and grain weight were positively correlated with stem weight (Enyi, 2008). An experiment with perennial orchid (*Dactylorhiza maculata)* showed that, the non-defoliated and partially defoliated plants produced relatively more heavier capsules than the completely defoliated plants (Vallius and Salonen, 2000). They added that, defoliation decreased the leaf area, corn mass and the probability of flowering the following year (Vallius and Salonen, 2000). Defoliation causes a decrease in seed production either due to decreased flower production (Stephenson, 1984; Meyer, 1998) or increased abortion of fruits and seeds (Obeso, 1993; Neisenbaun, 1996) or both (Juenger and Bergelson, 1997). Mondal *et al.* (2011) carried out experiment with two high and two low yielding Mungbean (*Vigna radiata*) genotypes at different levels of defoliation and result revealed that, the degree of defoliation decreased leaf area and total dry matter (TDM) production in respective of genotypes in Mungbean (Mondal *et al.,* 2011). They added that defoliation not only reduced source sizes but also decreased total sink (flower) production,

resulting in lower pod and seed yields in Mungbean (Mondal *et al.* 2011). One-third leaf removal from basal portion of the canopy in cowpea increased grain yield over control and severe defoliation decreased seed yield (Gustafson *et al*., 2006; Hossain *et al.,* 2006). Likewise, mild defoliation during reproductive phase did not adversely affect seed yield in Mungbean (*Vigna radiata*) (Pandey and Sight, 1984; Begun *et al.,* 1997) and in soybean (Board and Harville, 1998). Leaf is the major source of supplying assimilates to developing organs, young pods and seeds in crops (Abdi *et al.,* 2007; Mondal, 2007; Barimanvandi *et al.,* 2010). Leaf removal may therefore influence total dry matter production and yield through photosynthates production and distribution into different parts in Maize, Soybean and Cowpea, this depend on the magnitude of leaf removal (Chauhan and Halima, 2003; Gustafson *et al*., 2006 Hossain *et al*., 2006).

2.2 Leaves as a Source of Photosynthates

Wilkerson *et al*. (1984) stated that, defoliation altered the normal partitioning of photosynthates between plants parts in "florunner" peanuts. The loss of leaf area at any stage of the crop growth at various degrees of defoliation results in the reduction of net photosynthetic area, the higher the degree of defoliation the more the loss in seed yield and production. Khan and Lone (2005) concluded that, defoliation up to 50% of leaves of mustard (*Brassica juncea* L.) from lower half of the plant at pre- flowering or post flowering days after sowing , resulted in higher rate of photosynthesis, growth and yield at pre-flowering compared to defoliation at post flowering stage. Tulio *et al*. (2007) observed that defoliation by army worm (*Spodoptera fruugiperda* Smith) have reduced the rate of photosynthesis in wheat (*Triticum aestivum*) with time, though it was not significantly affected by any defoliation treatment. On the other hand, stomatal conductance was significantly reduced by time after defoliation and by the interaction between defoliation treatment and time after defoliation. Tulio *et al*. (2007) stated that a spatial

defoliation pattern has significantly reduced photosynthetic parameters of injured leaves, but responses were dependent on plant developmental stages.

2.3 Effect of Stages of Defoliation

Studies on defoliation of peanuts have suggested that severe defoliation after early vegetative stage reduced yields (Campbell, 1978; Turner, 1982; Santos and Sutton, 1983). Enyi (1975) reported that, in groundnut the greatest reduction in seed yield occurred when the plants were defoliated during early pod stage. At podding stage, complete defoliation recorded a reduction of 59.7 % when compared to 43.3 % to that of half defoliated in case of groundnut, cowpea and soybean. In a short season corn hybrid, 50 and 100 % defoliation at the 13 leaf stage reduced seed yield by 3.5 and 28.3 % respectively and of a full season corn hybrid by 0.1 and 30.8 % respectively (Hicks *et al*., 1977). Wilkerson *et al*. (1984) observed that defoliation imposed on florunner peanut plants at uniformly and non-uniformly at 9, 12 and 16 weeks after planting and harvested at 2, 4 or 6 weeks following treatment, all resulted in lower stem weight to length ratio, lower pods numbers and weights and equal or higher leaf numbers and weights.

Verma *et al*. (1992) reported that defoliation in soybean at any stage of the crop and at any level decreased the plant height. Kurtakoti (2001) observed that in soya bean, the growth parameters like number of leaf per plant and leaf area index were declined with increase in the defoliation level in all the stages of defoliation. Hanway (1969) reported that in case of corn 50% defoliation at 10^{th} and 16th leaf stages and blister stage reduced the average seed yield to 85, 70 and 80% respectively compare to that of check. Kurtakoti (2001) revealed that, in soybean, there was slight reduction in pods set percentage when the plants were defoliated at podding stage with successive increase in defoliation levels. This was followed by defoliation

at vegetative stage and the maximum reduction in pods setting was obtained when plants were defoliated at flowering stage.

Chaudhary *et al*. (2005) reported that, in maize, removal of tassel plus top four leaves at four weeks after mid-silking stage gave more seed yield as compared to defoliation of all leaves below cob at two weeks after mid-silking stage. Egharveba *et al.* (1976) observed that, in maize, when all leaves were removed at 10, 20 and 30 days after 50 % silking, the rate of dry matter accumulation was reduced significantly within 10 days, whereas, partial removal of leaves resulted in significant reduction within 20 days after the treatment because the partially defoliated plant retained at least 40 % of their total leaf area and these remaining leaves along with carbohydrate reserves stored in the stalk provided sufficient photosynthesis for translocation to the ear at a level compared to that in the non-defoliated plant for first the 10-20 days after defoliation. Defoliation at 40-50 days after 50 % silking caused no decrease in the rate of dry matter accumulation. After heavy grazing, the plants ability to increase leaf area and plant biomass is dependent on stage of vegetative development as well as severity of defoliation in winter wheat (Christiansen *et al*., 1998).

2.4 Effect of Defoliation on Growth Parameters

Defoliation reduced nodules formation and nitrogen fixation in a 'Vaginia' and a 'Spanish'-type peanut (*Arachis hypogaea*) (Osman *et al*., 1983). Williams *et al.* (1976) noticed that in groundnut, the plant growth rate was reduced to 82 and 59 % due to 50 and 75 % defoliation respectively. Defoliation decreased both stem and pod growth rates. David and Timothy (1991) observed that foliar-feeding insects or foliar-fungal pathogens significantly reduced vegetative characters and yield such as height, number of leaves, leaf area, leaf dry weight, number of

pods, pods dry weight, stem dry weight and stand density in 'florunner', 'sunrunner' and 'southern runner' peanuts (*Arachis hypogaea* L.).

Whiteman (1970) carried out experiments with *Desmodium uncinatum* and *Phaseolus atropurpureus,* to determine effect of defoliation on root nodules, the result revealed that, defoliation reduced the weight per nodule and the number of nodules increased per plant in both species. Kurtakoti (2001) observed reduction in soybean seed germination percentage, root length and shoot length with increase in level of defoliation at all the different stages of crop growth over the control. Brajesh and Sukumaran (2001) found that in potato, an artificial defoliation during the first two years when only top four leaves were retained, the reduction in total dry matter ranged from 40.3 to 50 %. Decio and Flavio (1997) defoliated soybean at different stages of development and the result revealed that intense defoliation affects vegetative regrowth and reduced seed yield. Severe defoliation is detrimental to regrowth of pasture legumes Phasey bean (*Macroptilium lathyroides* cv. Murray), an effect associated with reduced carbon assimilation and symbiotic nitrogen fixation (Othman *et al.,* 1992*).*

Diego *et al.* (1995) reported that defoliation delayed flowering in pearl millet and two cuts per year did not affect plant survival. The uncut plants grew taller than once cut due to well established root system from the previous year. However, defoliated plants were shorter in height with two cuts than the uncut plants by 0.9m; but seed production was not greatly affected. Tarawali *et al.* (1995) in forage crops found that, *Centrosema pascuorum* showed no regrowth due to cutting while *Stylosanthes hamata* produced the best regrowth. Frequent cutting generation increased regrowth, whereas single cutting produced more seedling than other treatment in all these species. El-douby *et al*. (2001) report that maize recorded the highest percentage of barren lodged and broken plants when total defoliation of the top most leaves occurred. White oat showed good leaf area recovery after grazing resulting in high dry

matter yield, provided that grazing period did not last more than four weeks (Bortoline *et al*., 2005). Nabi *et al*. (2012) concluded that, leaf defoliation in corn (*Zea mays* L.) significantly reduced plant height and ear height, seed weight decreased significantly with increasing leaf defoliation only in flowering stage. Legume-grass has a great influence on grassland primary production, its defoliation can increase the transfer of fixed nitrogen to a neighbouring grass (Saj *et al*., 2008). They reported that defoliation of plant can increase soil microbial activity and lead to better soil nitrogen availability in the rhizosphere of the defoliated plant. Repeated defoliation and flooding triggered opposite plant morphologies and both induced the consumption of carbohydrate reserves to sustain plant recovery (Gustavo *et al*., 2007).

2.5 Effect of Defoliation on Yield and Yield Attributes

In Nigeria leaf spot and rosette virus are the most serious damaging diseases of groundnut (Alabi *et al*., 1993). World-wide losses as high as 50 % due to *Cerscospora arachidicola* and *Cercospora personata* have been reported (Salako, 1987; Nyval, 1989; Dewaele and Swanevelder, 2001). Complete defoliation of Corn when 56 % of the plant had silked, decrease the seed yield up to 92 % and at the dent stage complete defoliation had no effect on yield as reported by Dungan and Woodworth (1970). Russel (1968) opined that, in corn, defoliation above the ear at vegetative growth stage reduced grain yields more than did defoliation below the ear. There was a reduction in shelling percentage by complete defoliation at all growth stages. Defoliation reduced pod yield, 100 kernel weight in groundnut variety ‘Dh8’ when defoliation exceeds 50% (Panchabhavi *et al*., 1986). Disease induced defoliation by *Cercosporidium personatum* significantly reduced the leaf dry weight and dry weight of the total biomass and subsequently caused serious yield losses of peanut (*Arachis hypogaea L.*) (Bourgeois, *et al.* 1991). Forrest *et al.* (1996) observed that, defoliation of peanut (caused by

Cercosporidium personatum) significantly reduced yield based on the percentage of defoliation.

Kalton *et al.* (1979) reported that, in soybean, complete defoliation reduced the oil percentage to an average of 17 % during seed development stage. Tarawali *et al.* (1995) observed that, defoliation at frequent level reduced both total dry matter and seed yield in legumes species (*Stylosanthus hamata* Tamb.) Pascorum. James *et al.* (2005) observed that, in trailing wild bean (*Strophostyles helvula* (L.) ELL. [Fabaceae]), light defoliation increased seed yield while herbage fibre concentration decreased and crude protein increased when defoliation occurred throughout the growing season. Karadogan and Akgun (2009) conducted an experiment with sunflower to determine the effect of leaf removal on yield, yield components and some other quality characters. The result revealed that, seed setting, seed yield, kernel ratio, crude oil yield and crude protein yield changed with different degree of leaf removal. These characters were affected in some ecotypes while they were not affected in some ecotypes. Defoliation of cowpea delayed plant recovery, flowering and decreased production parameters (pod number per plant, 100-seed weight, grain and residue dry matter yield) and grain revenue (Maposse and Nhempalele, 2009). However, leaf protein and leaf revenue increases with defoliation, while grain protein and residue crude protein concentrations were not affected by treatments (Maposse and Nhempalele, 2009).

Pandya (1975) found that in raya defoliation at the early growth stage adversely affected seed yield and the whole foliage appeared to play an equally important role in seed development. However, total defoliation reduced the seed yield by 37.5 %. This was indicative of a major photosynthetic contribution by green tissue other than leaves (e.g pods). At the late fruiting stage, the upper leaves contributed 32 % towards seed yield while the lower leaves played a negligible part. The upper leaves in spite of their small size/weight/area proved important,

probably due to their age, better access to sunlight and vicinity to the pods/seed (sink). Pods assimilation thus, made 68 % contribution towards seed production at the ripening stage, so these lower leaves may be plunked and profitably utilized for forage purposes without any decline in seed production. Bhattcharjee (1983) reported that, defoliation as low as 33 % even at pre flowering stage caused significant loss in pod number and seed yield in soybean.

Muralidhar (1990) concluded that, pod set and yield in many pulse crops decreased by the reduction in source capacity by partial defoliation or by shedding of leaves at the time of pods set. Pauli and Laude (1959) noticed decreased amount of protein and crude starch on per acre basis in seeds obtained from wheat plant completely defoliated within five days before heading whereas, losses were smaller in plant when defoliated after heading. Pauli and Stickler (1961) found that accumulation of dry matter, total sugar and nitrogen were reduced in plant and grains of Corn when partially or completely defoliated at anthesis. Leaf defoliation diminished 1000-grain weight and grain yield in all growth stages, though the slope of decrease in flowering stage was more than other stages (Nabi *et al*., 2012). George, *et al.* (2007) observed that, defoliation reduced yield in pea plant. Increasing leaf defoliation decreases grain yield in corn (National Crop Insurance Services, 1998). Thus both leaf loss and decreases in grain yield combined to reduce forage yield, greater forage yield decreases were measured with early defoliation than with late defoliation (Lauer *et al*., 2004).

2.6 Effect of Defoliation Levels on Plants

The reduction in plant dry weight, nodules number, nodules dry weight and nitrogenase activity was most severe for the 100 % defoliation treatment in groundnut (Osman *et al*., 1983). Yield of peanuts were reduced with defoliation of 33, 66 and 99% at the beginning of pod stage (Todd, 2008). However, only at the 99 % defoliation level and the beginning of pod stage

where yield reduced below 400 bags/acre (Todd, 2008). Endan *et al.* (2006) conducted an experiment with peanuts through hand defoliation at different levels of defoliation and the result revealed that, defoliation lowered the leaf, stem, root, peg and pods masses and pods weight.

In soybean, the percentage decrease in seed quality parameters, germination, seedling dry weight, vigour index and oil content increased with every 10 % increases in defoliation levels (10, 20, 30, 40 and 50 %), while the converse was noticed with electrical conductivity of seed leachate. The foliage loss of more than 20 % may be attributed to reduced supply and availability of food reserve to the growing embryo (Kurtakoti, 2001). Vasilas and Seif (1985) observed that, complete and 50 % defoliation reduced seed yield of five maize inbreeds by an average of 45.5 and 2.5 % respectively. Yield reduction with 50 % defoliation was due to reduction in ear number as opposed to kernels per ear, whereas, complete defoliation affected both yield components. Ear number was reduced both by decreasing the number of plant with double ears and increasing the number of barren plants. Hassan (2003) observed that, the seed yield and Stover yield of maize were significantly influenced by the rate of defoliation (0, 25, 50, 75 and 100 %) at various growth stages (late silking). Sagoe and Ankomah (2000) noticed that in cocoyam (*Xanthosoma spp*.), defoliation at two weekly interval recorded the highest reduction of 48.9 and 50.9 % leaf and petiole dry weight respectively, whereas a reduction of 7.5 and 7.2 % respectively was seen when defoliation was carried out at the three weekly intervals.

2.7 Insect and Disease Defoliation Effect on Plants

Cercospora species leaf spot and defoliating arthropods are the major pests which reduce the yield of peanut (*Arachis hypogaea* L.) in the south eastern United States by decreasing the

amount and effectiveness of photosynthetic surfaces (Boote *et al*., 1990). They reported that, photosynthesis of diseased canopies was reduced not only by loss of leaves which abscised as a result of infection, but also because diseased plants were less efficient in fixing Co_2. Early and late spot diseases that manifest as reddish brown to black necrotic spots on leaves caused premature defoliation and yield loss up to 70% in peanut (Shokes and Cul-breath, 1990; Waliyar *et al*., 2000). Leaf spot disease is the major foliar disease reducing groundnut yields wherever they are grown (Subrahamanyan *et al*., 1980). Cul-breath (2002) stated that, if not managed, early leaf spot (*Cercospora arachidicola*) and late spot (*Cercospodium personatum*) diseases of peanut can cause severe defoliation and yield losses on susceptible cultivars.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Research Site

The research was carried out in the botanical garden, Department Biological Sciences, Ahmadu Bello University, Zaria. The research was carried out in the rainy season from 18th March to 14th August, 2013.

3.2 Soil Collection

Garden top soil was collected from Botanical garden, Ahmadu Bello University, Zaria and river sand was collected from a river. The soil was analyzed in soil analysis laboratory, Department of Soil Science, Ahmadu Bello University, Zaria.

3.3 Seed Collection

Groundnut seeds were collected from Legume and Oilseeds Section, Institute for Agricultural Research, Samaru-Zaria.

SAMNUT 21 the seed colour is variegated (tan and white), SAMNUT 22 the seed colour is tan and SAMNUT 23 seed colour is red, from the Institute for Agricultural Research, Samaru, Zaria. While SAMNUT 24 seed colour is tan from the same Institute.

3.4 Soil Preparation and Pot Filling

The sands and top soils were thoroughly homogenized in the proportion of 1:1, this was used to fill the polythene bags.

3.5 Sowing

Four groundnut varieties (SAMNUT 21, SAMNUT 22, SAMNUT 23 and SAMNUT 24) were grown in the Botanical garden. The seeds were sown after treating with fungicide (APRON STAR) at the rate of 10g per 4 kg of groundnut, and then 4 seeds were sown per polythene bag and thinned to two plants in each polythene bag at 2 Week After Planting (WAP).

3.6 Watering

The pots soils were watered to field capacity at two days interval until harvest.

3.7 Experimental Design

The groundnut varieties were subjected to five different levels of defoliation as follows: 0 (control), 25, 50, 75 and 100 % defoliation at 5 WAP. The defoliation was from the base towards the top of the plants. The experiment was replicated thrice and each replicate was represented with 8 pots. A total of 480 pots were used in this experiment and laid out in a complete randomized design.

3.8 Weed Control

The plants were hand weeded at 2, 5 and 8 WAP.

3.9 Fertilizer Application

Fertilizer was applied by side placement. Single superphosphate (P_2O_4) fertilizer was applied at planting at the rate of 22.0 KgP_2O_4/ha.

3.10 Meteorological Data

Meteorological data was collected from meteorological unit, Institute for Agricultural Research, Ahmadu Bello University, Zaria.

3.11 Parameters Measured

3.11.1 Flower count

Beginnings at 5 WAP, the flowers were counted from each plant at a week interval to determine the effect of defoliation on flowering.

3.11.2 Sampling of the plant

One polythene bag was sampled per each replicate of treatments at 3 weeks interval starting from 4 WAP. The pot soil was carefully removed from the plant in order to recover most of the roots. The sampled plant was washed in water and then drained on clean table in the laboratory.

3.11.3 Vegetative parameters

3.11.3.1 Plant height

Three of the washed plants from each treatment were selected for determination of growth parameters. The height of the three sampled plants from each treatment were measured using metre rule from ground level to the tip of the plant (central stalk was used) at 4, 7 and 10 WAP.

3.11.3.2 Root nodules count

At 10 WAP, the root nodules of the three sampled plants were counted**.**

3.11.3.3 Dry matter accumulation

Beginning from the 4 WAP, two plants per replicate were sampled for assessment of dry matter accumulation at 3 week interval until 10 WAP. The sampled plants were then partitioned into roots and shoot. Each component was placed in labelled envelope and dried in an oven set at 70^0C to a constant weight and were reweighed using a top-loading mettler balance.

3.11.3.4 Relative growth rate (RGR)

Relative growth rate, which is a measure of the increase in plant material per unit of initial material per unit of time (Hoffmann and Poorter, 2002) was calculated using the data obtained on dry weight at 4, 7 and 10 WAP.

The relative growth rate value was computed using the following formula

$$RGR = \frac{\log_e W2 - \log_e W1}{T2-T1} \text{ (g/g/wk)}$$

Where W1= initial dry weight of groundnut plant in grams

W2=final dry weight of groundnut plant in grams

T1= initial time in weeks

T2= final time in weeks

$\log_e$ = natural logarithm to the base e, where e is an irrational and transcendental

Constant approximately equal to 2.718281828

3.11.4 Yield parameters

3.11.4.1 Harvesting

This was done as soon as there are indications that the majority of the nuts had darkened veins, the outside becomes spongy and the veins pronounced. At this stage all the leaves had turned yellowish in colour and some senesced and dropped. This was done by carrying the whole polythene bag and breaks it on the floor carefully, and then the plant with the pods was removed and washed in tap water.

3.11.4.2 Total number of pods per plant

At harvest the numbers of pods (both matured and immature) from the six selected plants from each treatment replicate were counted.

3.13.3.3 Number of matured pods per plant

At harvest six plants were selected at random from each treatment replicate and the numbers of matured pods were counted.

3.11.4.4 Number of immatured pods per plant

The numbers of immatured pods were counted from the six selected plants from each treatment replicate at harvest.

3.11.4.5 Weight of dry pods per plant

These pods from the plants under each treatment were air-dried to constant weight. The weight of all the pods harvested from the plants from each treatment replicate was determined using Mettler balance. After weighing the dry groundnut pods harvested from each treatment replicate, pod dry weight was then converted to yield/plant by dividing such with the number of plants harvested.

3.11.4.6 Weight of seeds per plant

This was determined by shelling the pods from the plants sampled. The seeds from the plants were weighed using a top-loading Mettler balance. The mean value per plant was determined by dividing the weight by the number of plants harvested.

3.11.4.7 Shelling percentage

Shelling percentage is express as the percentage of weight of kernels per weight of unshelled pods. This was obtained using the kernels weight and the pods weight from the plants from each treatment replicate.

$$\text{Shelling percentage} = \frac{\text{Weight of kernels}}{\text{Weight of pods}} \times 100$$

3.11.4.8 100-seeds weight

After shelling, 100 kernels were randomly taken from the seeds harvested from each treatment replicate and weighed using a top-loading Mettler balance.

3.11.4.9 Haulm weight per plant

The haulm from the plants harvested was weighed from each treatment. The average haulm weight per plant was obtained by dividing the total weight by the number of plants. The weight of the haulms from each treatment replicate was converted to haulm yield per plant.

3.12 Statistical Analysis

Data obtained from the study were subjected to analysis of variance (ANOVA) using SPSS version 21 to determine the effect of the treatments. Duncan multiple range test (DMRT) was used for comparison of means.

CHAPTER FOUR

4.0 RESULTS

4.1 Plant Height

The 75% defoliation resulted in the highest plant height at 7 and 10 week after planting (WAP) in varieties SAMNUT 21and SAMNUT 23 and at 7 WAP and 10 WAP in SAMNUT 24 and 22 respectively (Table 4.1). On other hand, 50% defoliation resulted in the lowest plant height at 4 and 7 week after planting in varieties SAMNUT 21 and SAMNUT 23 (Table 4.1).

4.1.1 SAMNUT 21

At 4 WAP, 25% defoliation of groundnut variety SAMNUT 21 resulted in the highest plant height which was only significantly higher than the lowest due to 50% defoliation (Table 4.1). At 7 WAP, the highest plant height was observed in variety SAMNUT 21 due to 75% defoliation was not significantly higher than the lowest due to 50% defoliation (Table 4.1). At 10 WAP, the highest plant height due to 75% defoliation was not significantly ($P \geq 0.05$) higher than the lowest due to 25% defoliation (Table4.1).

4.1.2 SAMNUT 22

At 4 WAP, the lowest plant height of groundnut variety SAMNUT 22 due to 100% defoliation was only significantly lower than the highest due to the control. At 7 WAP the highest plant height due to the control (0%) was only significantly higher than the lowest due to 100% defoliation. At 10 WAP, 75 and 100% defoliation of groundnut variety SAMNUT 22 resulted in the highest plant height which was only significantly higher than the lowest due to 25% defoliation (Table 4.1).

Table 4.1 Effect of Defoliation on the Plant Height (cm) of four Groundnut Varieties

Variety	Defoliation level (%)	Plant Age (WAP) Plant Height (cm) 4	7	10
SAMNUT 21	0	15.73a	19.43a	16.13a
	25	15.87a	19.27a	10.90a
	50	12.30b	16.67a	14.40a
	75	15.83a	21.00a	16.30a
	100	13.57ab	19.03a	16.20a
	Mean	14.67	19.08	14.79
	SE $\pm$	1.02	1.92	2.72
SAMNUT 22	0	18.50a	25.30a	21.13ab
	25	16.40ab	23.87ab	17.17b
	50	15.80b	22.73ab	19.60ab
	75	17.13ab	24.33ab	25.50a
	100	15.23b	20.00b	25.50a
	Mean	16.61	23.25	21.78
	SE $\pm$	0.79	1.31	1.79
SAMNUT 23	0	14.77ab	18.10b	17.00a
	25	17.17a	18.20b	20.30a
	50	12.50b	15.33b	17.33a
	75	15.40ab	22.20a	22.97a
	100	14.83ab	16.80b	22.93a
	Mean	14.93	18.13	20.11
	SE $\pm$	1.17	1.15	2.03
SAMNUT 24	0	14.50b	21.27ab	21.00b
	25	13.53b	20.27abc	14.33c
	50	12.83b	17.30bc	24.40b
	75	16.10ab	24.47a	24.50b
	100	19.20a	14.53c	30.07a
	Mean	15.23	19.57	22.86
	SE $\pm$	1.04	1.78	1.58
	Interaction:	S	Ns	Ns

Note: Means followed by the same letter(s) in each column, under each variety are not significantly different ($P \geq 0.05$), using DMRT. S= Significant, NS= Not Significant, WAP= Weeks After Planting

4.1.3 SAMNUT 23

At 4 WAP, 25% defoliation of groundnut variety SAMNUT 23 resulted in the highest plant height which was only significantly higher than the lowest due to 50% defoliation (Table 4.1). At 7 WAP, the lowest plant height due to 50% defoliation was only significantly lower than the highest due to 75% defoliation. At 10 WAP, the highest plant height was due to 75% defoliation (Table 4.1).

4.1.4 SAMNUT 24

At 4 WAP, 50% defoliation of groundnut variety SAMNUT 24 resulted in the lowest plant height which was only significantly lower than the highest due to 100% defoliation (Table 4.1). At 7 WAP, 75% defoliation of groundnut variety SAMNUT 24 produced the highest plant height which was similar with that of the control (0%) and 25% defoliation. The lowest plant height due to 100% defoliation was similar with that due to 25 and 50% defoliation. At 10 WAP, 100% defoliation produced the highest plant height and this was followed by those due to 75%, 50% and the control defoliation. The lowest plant height was due to 25% defoliation was significantly lower than that of the other (Table 4.1).

The combined analysis of the data for showed that, defoliation had significant effect on groundnut cultivars plant height at 7 and 10 WAP. The highest plant height was due to 75% defoliation at 4 and 7 WAP, but due to 100% defoliation at 10 WAP. The lowest plant height was at 4 WAP and 7 WAP which were due to 50% and 100% defoliation. The combined analysis of data on varieties also showed that, SAMNUT 22 had the highest plant height at 4 and 7 WAP but at 10 WAP it was SAMNUT 24. The lowest plant height was due to SAMNUT 21 at 4 and 10 WAP and due to SAMNUT 23 at 7 WAP (Table 4.2).

Table 4. 8: Combined analysis of the effect of defoliation on vegetative parameters of four groundnut cultivars

Defoliation level (%)	Plant Age (WAP) Plant height (cm)			Plant Age (WAP) Shoot dry matter (g)			Plant Age (WAP) Root dry matter (g)			Root nodule number/ plant	Plant Age (WAP) Shoot RGR (g/g/wk)		Plant Age (WAP) Root GRG (g/g/wk)	
	4	7	10	4	7	10	4	7	10	10	4-7	7-10	4-7	7-10
0	15.88a	21.03ab	18.82b	0.98a	5.19a	8.47a	0.13ab	0.85a	1.32a	126.67ab	13.24a	18.33a	2.19ab	2.81a
25	15.74a	20.40b	15.68c	0.92a	4.20b	7.66ab	0.13ab	0.66ab	1.37a	131.92a	10.59ab	17.03ab	1.67bc	3.09a
50	13.36b	18.01c	18.93b	0.94a	4.79ab	7.20abc	0.13ab	0.78a	1.08ab	106.92bc	12.19ab	15.24ab	2.47a	2.26ab
75	16.12a	23.00a	22.32a	0.95a	4.15b	6.31bc	0.16a	0.54b	0.83b	87.17dc	10.43b	13.40b	1.27c	1.76b
100	15.71a	17.59c	23.68a	0.87a	2.71c	6.04c	0.10b	0.50b	0.78b	79.17d	6.58c	13.98b	1.27c	1.65b
Variety														
SAMNUT 21	14.66b	19.08b	14.79b	1.01a	3.97a	7.25ab	0.19a	0.75a	1.51a	97.00b	9.89a	16.13ab	2.24a	3.44a
SAMNUT 22	16.61a	23.25a	21.78a	0.82b	4.48a	7.09ab	0.11b	0.83a	1.34a	121.73a	11.45a	15.24ab	2.15a	2.89a
SAMNUT 23	14.93b	18.13b	20.11a	1.10a	4.46a	8.03a	0.12b	0.52b	0.73b	103.07ab	11.13a	17.81a	1.28b	1.49b
SAMNUT 24	15.23b	19.57b	22.86a	0.79b	3.92a	6.16b	0.11b	0.56b	0.71b	103.66ab	9.95a	13.21b	1.43b	1.42b

Note: Means followed by the same letter(s) in each column, under each parameter, age, and variety section are not significantly different (P = 0.05), using DMRT.

4.2 Shoot Dry Matter

The control resulted in the highest shoot dry matter at 7 and 10 WAP in varieties SAMNUT 21 and SAMNUT 24 while at the same period the highest shoot dry matter was due to 25% defoliation in SAMNUT 23 (Table 4.3). On other hand, 100% defoliation resulted in the lowest shoot dry matter at 7 WAP in all the varieties and in SAMNUT 22 and SAMNUT 24 at 10 WAP (Table 4.3).

4.2.1 SAMNUT 21

At 4 WAP, 25% defoliation of groundnut variety SAMNUT 21 resulted in the lowest shoot dry matter which was significantly lower than the highest due to 75% defoliation (Table 4.3). At 7 WAP, the highest shoot dry matter in variety SAMNUT 21 due to the control was only similar with that due to 50% defoliation. These were followed by that due to 25 and 75% defoliation (Table 4.3). The lowest shoot dry matter in SAMNUT 21 at 7 WAP due to 100% defoliation was significantly lower than that of the other. At 10 WAP, the highest shoot dry matter was due to the control and the lowest was due to 25% defoliation. However, this difference in shoot dry matter at 10 WAP was not significant ($P \geq 0.05$) (Table 4.3).

4.2.2 SAMNUT 22

At 4 WAP, 50% defoliation of groundnut variety SAMNUT 22 resulted in the lowest shoot dry matter which was only significantly lower than the highest due to 25% defoliation (Table 4.3). At 7 WAP, the highest shoot dry matter due to 50% defoliation was only significantly higher than the lowest due to 100% defoliation (Table 4.3). At 10 WAP, the highest shoot dry matter due to 25% defoliation was only significantly higher than the lowest due to 100% defoliation (Table 4.3).

Table 4.3 Effect of Defoliation on the Shoot Dry Matter of four Groundnut Varieties**.**

		Age of plant (WAP) Shoot dry matter (g)		
Variety	Defoliation level (%)	4	7	10
SAMNUT 21	0	1.10ab	5.27a	8.83a
	25	0.73b	3.70b	6.30a
	50	0.87b	4.63ab	6.70a
	75	1.37a	3.73b	6.97a
	100	1.00ab	2.53c	7.47a
	Mean	1.01	3.97	7.25
	SE ±	0.12	0.33	1.21
SAMNUT 22	0	0.83ab	4.93a	7.53ab
	25	1.00a	4.53ab	8.67a
	50	0.60b	5.40a	7.37a
	75	0.87ab	4.63ab	7.60ab
	100	0.80ab	2.90b	4.30b
	Mean	0.82	4.48	7.09
	SE ±	0.09	0.55	1.07
SAMNUT 23	0	1.00b	5.30ab	8.90a
	25	1.20ab	6.10a	9.73a
	50	1.47a	4.60ab	8.47a
	75	0.90b	3.23b	3.97b
	100	0.93b	3.07b	9.10a
	Mean	1.10	4.46	8.03
	SE ±	0.11	0.68	0.85
SAMNUT 24	0	1.00a	5.27a	8.60a
	25	0.73b	2.47b	5.93a
	50	0.83ab	4.53a	6.27a
	75	0.67b	5.00a	6.70a
	100	0.73b	2.33b	3.30b
	Mean	0.79	3.92	6.16
	SE ±	0.07	0.63	0.81
	Interaction:	S	S	S

Note: Means followed by the same letter(s) in each column, under each variety are not significantly different ($P \geq 0.05$), using DMRT. S= Significant, NS= Not Significant, WAP= Weeks After Planting

4.2.3 SAMNUT 23

At 4 WAP, the lowest shoot dry matter in variety SAMNUT 23 due to 75% defoliation was only significantly lower than the highest due to 50% defoliation (Table 4.3). At 7 WAP, 100% defoliation of groundnut variety SAMNUT 23 resulted in the lowest shoot dry matter which was significantly lower than the highest due to 25% defoliation. At 10 WAP, the highest shoot dry matter due to 25% defoliation was only significantly higher than the lowest due to 75% defoliation (Table 4.3).

4.2.4 SAMNUT 24

At 4 WAP, the lowest shoot dry matter in variety SAMNUT 24 due to 75% defoliation was significantly lower than the highest due to control (Table 4.3). At 7 WAP, the highest shoot dry weight due to the control was comparable with that due to 50 and 75% defoliation. The lowest shoot dry weight due to 100% defoliation was only similar to that due to 25% defoliation. At 10 WAP, the highest shoot dry matter due to control was only significantly higher than the lowest due to 100% defoliation (Table 4.3).

The combined analysis of the data showed that, defoliation significantly reduced the shoot dry matter of groundnut varieties at 7 and 10 WAP. The highest shoot dry matter was due to the control at 4, 7 and 10 WAP while the lowest was due to 100% defoliation in groundnut varieties. The combined ANOVA on varieties indicated that, the highest shoot dry matter was obtained in SAMNUT 23 at 4 and 10 WAP but in SAMNUT 22 at 7 WAP. The lowest shoot dry matter due to defoliation was in SAMNUT 24 on each sampling date (Table 4.2).

4.3 Root Dry Matter and Nodules

4.3.1 Root dry matter

Defoliation had no significant effect on the root dry matter of most varieties at 4 and 7 WAP. The 25% defoliation resulted in the highest root dry matter at 4 and 10 WAP in varieties SAMNUT 22 and SAMNUT 23. On other hand, 75% defoliation resulted in the lowest root dry matter at 7 and 10 WAP in varieties SAMNUT 21 and SAMNUT 23 (Table 4.4).

4.3.1.1 SAMNUT 21

At 4 WAP 100% defoliation of groundnut variety SAMNUT 21 resulted in the lowest root dry matter was only significantly lower than the highest due to 75% defoliation (Table 4.4). At 7 WAP, the highest root dry weight in variety Samnut 21 due to the control was not significantly higher than the lowest due to 75% defoliation (Table 4.4). At 10 WAP, the highest root dry matter due to control was not significantly higher than the lowest due to 75% defoliation (Table 4.4).

4.3.1.2 SAMNUT 22

At 4 WAP, 25% defoliation of groundnut variety SAMNUT 22 resulted in highest root dry matter (Table 4.4). At 7 WAP, the highest root dry weight due to the control was also not significantly higher than the lowest due to 100% defoliation (Table 4.4). At 10 WAP, the highest root dry matter due to 25% defoliation was similar to that of the control and 50% defoliation. The lowest root dry matter due to 100% defoliation was similar to that due to 75% defoliation (Table 4.4).

Table 4.4 Effect of Defoliation on Root Dry Matter and Nodule of four Groundnut Varieties.

Variety	Defoliation level (%)	Plant Age (WAP) Root dry matter (g) 4	7	10	Root nodule number/plant 10
SAMNUT 21	0	0.23ab	1.00a	2.03a	137.33a
	25	0.13b	0.80a	1.70a	103.67ab
	50	0.13b	0.70a	1.37a	91.67ab
	75	0.33a	0.60a	1.03a	74.33b
	100	0.10b	0.63a	1.43a	78.00b
	Mean	0.19	0.75	1.51	97.00
	SE ±	0.05	0.15	0.34	15.48
SAMNUT 22	0	0.10a	0.97a	1.47ab	108.00b
	25	0.13a	0.87a	1.87a	160.67a
	50	0.10a	0.90a	1.40ab	136.00ab
	75	0.10a	0.80a	1.17bc	103.33b
	100	0.10a	0.60a	0.80c	100.67b
	Mean	0.11	0.83	1.34	121.73
	SE ±	0.02	0.17	0.17	12.28
SAMNUT 23	0	0.10a	0.57a	0.67a	116.33ab
	25	0.17a	0.63a	1.07a	128.33a
	50	0.13a	0.60a	0.87a	111.67abc
	75	0.10a	0.37a	0.50a	83.33bc
	100	0.10a	0.47a	0.53a	75.67c
	Mean	0.12	0.53	0.73	103.07
	SE ±	0.02	0.10	0.22	11.74
SAMNUT 24	0	0.10a	0.87a	1.10a	145.00a
	25	0.10a	0.33b	0.83ab	135.00ab
	50	0.13a	0.90a	0.70abc	88.33bc
	75	0.10a	0.40b	0.60bc	87.67bc
	100	0.10a	0.30b	0.33c	62.33c
	Mean	0.11	0.56	0.71	103.67
	SE ±	0.02	0.15	0.14	15.90
	Interaction:	S	Ns	Ns	Ns

Note: Means followed by the same letter(s) in each column, under each variety are not significantly different ($P \geq 0.05$), using DMRT. S= Significant, NS= Not Significant, WAP= Weeks After Planting

4.3.1.3 SAMNUT 23

At 4, 7 and 10 WAP, 25% defoliation of groundnut variety SAMNUT 23 resulted in the highest root dry matter (Table 4.4).

4.3.1.4 SAMNUT 24

At 4 WAP, 50% defoliation of groundnut variety SAMNUT 24 resulted in the highest root dry matter (Table 4.4). At 7 and 10 WAP, the lowest root dry weight due to 100% defoliation was significantly lower than that due to the control and 50% defoliation of groundnut variety SAMNUT 24 at 7 WAP and that of the control and 25% defoliation at 10 WAP (Table 4.4).

The combined analysis of the data showed that, 75 and 100% defoliation of groundnut varieties significantly reduced root dry matter at 7 and 10 WAP (Table 4.2). The lowest root dry matter was due to 100% defoliation in groundnut varieties. The combined analysis of the data for varieties also showed that, the highest root dry matter due to defoliation in SAMNUT 21 at 4 WAP, SAMNUT 22 at 7 WAP and SAMNUT 23 at 10 WAP. The lowest root dry matter was in SAMNUT 22, SAMNUT 23 and SAMNUT 24 at 4, 7 and 10 WAP respectively (Table 4.2).

4.3.2 Root nodules

The highest root nodules number at 10 WAP, was due to the control in SAMNUT 21 and 24 varieties and in varieties SAMNUT 22 and SAMNUT 23 by 25% defoliation. On the other hand, the lowest number of nodules in SAMNUT 22, 23 and 24 was due to 100% defoliation (Table 4.4).

4.3.2.1 SAMNUT 21

At 10 WAP, the lowest root nodule number due to 100% defoliation was only significantly lower than the highest due to the control (Table 4.4).

4.3.2.2 SAMNUT 22

At 10 WAP, the lowest root nodule number due to 100% defoliation was only significantly lower than the highest due to 25% defoliation (Table 4.4).

4.3.2.3 SAMNUT 23

At 10 WAP, 25% defoliation of groundnut variety Samnut 23 resulted in the highest root nodule number was comparable with that of the control (0%) and 50% defoliation. The lowest root nodule number due 100% defoliation was also similar to that due 50 and 75% defoliation (Table 4.4).

4.3.2.4 SAMNUT 24

At 10 WAP, the control treatment of groundnut variety SAMNUT 24 produced the highest root nodules number which was comparable to that due to 25% defoliation. The lowest root nodules number due to 100% defoliation treatment was comparable with that due to 50 and 75% defoliation treatment (Table 4.4).

The combined analysis of the data revealed that, the highest root nodule due to 25% defoliation was similar to that of the control. The lowest root nodules number due to 100% defoliation in groundnut varieties was significantly lower than all others. The combined analysis for varieties revealed that, the highest root nodules obtained in SAMNUT 22 was only significantly higher than the lowest of SAMNUT 21 (Table 4.2).

4.4 Relative Growth Rate (RGR)

4.4.1 Shoot relative growth rate

At both 4-7 and 7-10 WAP, the control in varieties SAMNUT 21 and SAMNUT 24 and 25%

defoliation and in SAMNUT 23 produced the highest shoot relative growth rate. At 4-7 WAP, the highest shoot relative growth rate (RGR) in groundnut varieties SAMNUT 21 and SAMNUT 24 due to the control treatment was comparable with that due to 50% defoliation. On the other hand, at 4-7 WAP the lowest shoot relative growth rate was due to 100% defoliation in all the four varieties (Table 4.5).

4.4.1.1 SAMNUT 21

At 4-7 WAP, the highest shoot RGR in groundnut variety SAMNUT 21 was similar to that due to 50% defoliation. These were followed with that due to 25 and 75% defoliation. The lowest shoot RGR due to 100% defoliation was significantly lower than that of the other (Table 4.5). At 7-10 WAP, the highest shoot RGR due to the control was not significantly higher than the lowest due to 25% defoliation (Table 4.5).

4.4.1. 2 SAMNUT 22

At 4-7 WAP, the highest shoot RGR in groundnut variety SAMNUT 22 due to 50% defoliation was only significantly higher than the lowest due to 100% defoliation.

At 7-10 WAP, the highest shoot RGR due to 25% defoliation was significantly higher than the lowest due to 100% defoliation (Table 4.5).

4.4.1.3 SAMNUT 23

At 4-7 WAP, the lowest shoot RGR in groundnut varieties SAMNUT 23 due to 100% defoliation was significantly lower than the highest due to 25% defoliation. At 7-10 WAP, the highest shoot RGR due to 25% defoliation was significantly higher than the lowest due to 75% defoliation (Table 4.5).

Table 4.5 Effect of Defoliation on Shoot and Root Relative Growths Rate of four Groundnut Varieties

Variety	Defoliation level (%)	Plant Age (WAP) Shoot Relative Growth Rate (g/g/wk		Root Relative Growth Rate (g/g/wk)	
		4-7	7-10	4-7	7-10
SAMNUT 21	0	13.34a	19.25a	2.51ab	4.63a
	25	9.40b	13.78a	2.05ab	3.90a
	50	11.82ab	14.02a	3.70a	3.09a
	75	8.92b	15.57a	1.33b	2.27a
	100	5.98c	18.01a	1.63ab	3.32a
	Mean	9.89	16.13	2.24	3.44
	SE ±	0.52	1.87	0.40	0.54
SAMNUT 22	0	12.66a	16.03ab	2.54a	3.11ab
	25	11.42ab	19.47a	2.24a	4.30a
	50	14.16a	15.14ab	2.36a	2.99ab
	75	11.82ab	16.48ab	2.08a	2.45b
	100	7.16b	9.07b	1.54a	1.64b
	Mean	11.45	15.24	2.15	2.90
	SE ±	0.86	1.67	0.27	0.30
SAMNUT 23	0	13.51ab	19.40a	1.45a	1.30a
	25	15.51a	20.95a	1.57a	2.32a
	50	11.18ab	18.86a	1.52a	1.82a
	75	7.98b	7.86b	0.66a	1.03a
	100	7.50b	21.98a	1.18a	1.03a
	Mean	11.13	17.81	1.28	1.50
	SE ±	1.04	1.50	0.17	0.31
SAMNUT 24	0	13.43a	18.63a	2.26a	2.21a
	25	6.05b	13.91a	0.82b	1.85ab
	50	11.58a	12.95a	2.33a	1.15ab
	75	12.99a	13.71a	0.99ab	1.27ab
	100	5.68b	6.86b	0.72b	0.64b
	Mean	9.95	13.21	1.43	1.42
	SE ±	0.97	1.11	0.23	0.23
	Interaction:	S	S	Ns	Ns

Note: Means followed by the same letter(s) in each column, under each variety are not significantly different ($P \geq 0.05$), using DMRT. S= Significant, NS= Not Significant, WAP= Weeks After Planting

4.4.1.4 SAMNUT 24

At 4-7 WAP, the highest shoot RGR in groundnut variety SAMNUT 24 due to the control was similar to that due to 50 and 75% defoliation. The lowest RGR due to 100% defoliation was similar to that due to 25% defoliation. At 7-10 WAP, the highest shoot RGR was only significantly higher than the lowest due to 100% defoliation (Table 4.5).

The combined analysis of the data on shoot relative growth rate showed that, the highest shoot relative growth rate was significantly higher than that due to 100 and 75% defoliation at 4-7 and 7-10 WAP. The combined analysis for varieties showed that the highest RGR obtained in SAMNUT 22 at 4-7 WAP and SAMNUT 21 at 7-10 WAP were not significantly higher than that due to most of the other groundnut cultivars at each stage of growth (Table 4.2).

4.4.2 Root relative growth rate

At 4-7 WAP, the highest root RGR was due to 50% defoliation in groundnut varieties SAMNUT 21 and SAMNUT 24 (Table 4.7). The lowest shoot RGR was due to 75% defoliation in groundnut varieties SAMNUT 21 and SAMNUT 23 and due to 100% defoliation in varieties SAMNUT 22 and SAMNUT 24 (Table 4.7). At 7-10 WAP, the highest root RGR was due to the control in groundnut varieties SAMNUT 21 and SAMNUT 24 while it was due to 25% defoliation in groundnut varieties SAMNUT 22 and SAMNUT 23 (Table 4.5).

4.4.2.1 SAMNUT 21

At 4-7 WAP, the highest root RGR in groundnut variety SAMNUT 21 due to 50% defoliation was significantly higher than the lowest due 75% defoliation. At 7-10 WAP, the highest root RGR was not significantly higher than the lowest due to 75% defoliation (Table 4.5).

4.4.2.2 SAMNUT 22

At 4-7 WAP, the highest root RGR in groundnut variety SAMNUT 22 was not significantly higher than the lowest due to 100% defoliation. At 7-10 WAP, the lowest root RGR due to 100% defoliation was only lower than the highest due to 25% defoliation (Table 4.5).

4.4.2.3 SAMNUT 23

At 4-7 WAP, the highest root RGR in groundnut variety SAMNUT 23 due to 25% defoliation was not significantly higher than the lowest due to 75% defoliation (Table 4.5). At 7-10 WAP, the highest root RGR due to 25% defoliation was not significantly higher than the lowest due to 75 and 100% defoliation (Table 4.5).

4.4.2.4 SAMNUT 24

At 4-7 WAP, the highest root RGR in groundnut variety SAMNUT 24 due to 50% defoliation was similar to the control and 75% defoliation. The lowest root RGR due to 100% defoliation was lower than the control and 50% defoliation (Table 4.5). At 7-10 WAP, the highest root RGR due to the control was only significantly higher than the lowest due to 100% defoliation (Table 4.5).

The combined analysis showed that, the highest root RGR due to 50 and 25% defoliation at 4-7 and 7-10 WAP respectively was significantly higher than that due to 75 and 100% defoliation at both ages. The combined analysis for varieties also showed that the highest root RGR due to defoliation was in SAMNUT 21 at both growth stages was significantly higher than that of SAMNUT 23 and SAMNUT 24 at each growth stage (Table 4.2).

4.5 Yield

4.5.1 Flower count

The highest flower count in all the varieties occurred at 6 WAP, subsequently flower count declined till 10 WAP (Table 4.6). At 6 and 7 WAP, the control had the highest flower/plant in varieties SAMNUT 21 and SAMNUT 22, while the lowest was due to 100% defoliation (Table 4.6). The control had the highest flower in varieties SAMNUT 22 and SAMNUT 23 at 8 WAP and in varieties SAMNUT 21 and SAMNUT 23 at 9 WAP. At 8 and 9 WAP the lowest flower was due to 100% defoliation in varieties SAMNUT 21, SAMNUT 22 and SAMNUT 23 (Table 4.6).

4.5.1.1 SAMNUT 21

At 6 WAP, the highest flower count of groundnut variety SAMNUT 21 was the control and was only significant higher ($P \geq 0.05$) than the lowest due to 100% defoliation.

At 7 WAP, the groundnut variety SAMNUT 21, had the highest flower (Table 4.6).

At 8 WAP, 50% defoliation was highest but not significantly higher than the lowest due to 100% defoliation (Table 4.6).

At 9 WAP, the highest flower number in SAMNUT 21 was significantly higher than the lowest due to 75 and 100% defoliation (table 4.6).

At 10 WAP, the highest flower number due to 25 and 50% defoliation was not significantly higher than the lowest due to 100% defoliation (Table 4.6).

Table 4.6 Effect of Defoliation on Flower Production of four Groundnut Varieties

Variety	Defoliation level (%)	Plant Age (WAP) Flower count 6	7	8	9	10	TOTAL
SAMNUT 21	0	3.67a	3.00a	0.67a	1.67a	1.33a	11.00a
	25	2.33ab	2.33a	1.00a	1.67a	1.67a	9.00ab
	50	2.67ab	2.67a	1.33a	0.67ab	1.67a	9.00ab
	75	2.67ab	2.33a	0.67a	0.33b	1.33a	7.33ab
	100	2.00b	1.67a	0.67a	0.33b	1.00a	5.67b
	Mean	2.67	2.40	0.87	0.93	1.40	8.40
	SE ±	0.47	0.47	0.29	0.33	0.39	1.12
SAMNUT 22	0	3.67a	2.67a	1.00a	1.67a	2.00a	11.00a
	25	3.33a	2.67a	1.00a	1.33a	2.00a	10.33a
	50	3.67a	2.67a	1.00a	2.00a	1.33a	10.67a
	75	3.00a	2.67a	0.67a	1.00a	1.00a	8.33a
	100	3.00a	1.67a	0.67a	1.33a	1.00a	7.67a
	Mean	3.33	2.47	0.87	1.47	1.47	9.60
	SE ±	0.37	0.67	0.33	0.37	0.29	1.20
SAMNUT 23	0	3.33a	0.67a	0.33a	0.33a	0.00a	4.67a
	25	4.33a	0.33a	0.00a	0.00a	0.33a	4.67a
	50	4.33a	0.67a	0.00a	0.33a	0.33a	5.67a
	75	4.00a	0.33a	0.00a	0.00a	0.33a	4.67a
	100	4.00a	1.00a	0.00a	0.00a	0.00a	5.00a
	Mean	4.00	0.60	0.07	0.13	0.20	4.93
	SE ±	0.45	0.29	0.15	0.21	0.26	0.80
SAMNUT 24	0	4.00ab	1.00a	0.00a	0.33a	0.33a	5.67bc
	25	5.00ab	1.33a	0.33a	0.33a	1.00a	8.00ab
	50	5.67a	1.00a	0.67a	0.67a	0.67a	8.67a
	75	3.67b	0.67a	0.67a	0.33a	0.33a	5.67bc
	100	3.67b	0.6a	0.00a	0.00a	0.33a	4.67c
	Mean	4.40	0.93	0.33	0.33	0.25	6.53
	SE ±	0.58	0.26	0.26	0.29	0.29	0.87
	Interaction:	Ns	Ns	Ns	Ns	Ns	Ns

Note: Means followed by the same letter(s) in each column, under each variety are not significantly different ($P \geq 0.05$), using DMRT. S= Significant, NS= Not Significant, WAP= Weeks After Planting

4.5.1.2 SAMNUT 22

The effect of defoliation on flower production in SAMNUT 22 was not significant on any of the sampling dates (Table 4.6).

At 6-8 and 10 WAP, defoliation at 0, 25 and 50% levels produced the highest flower number. Conversely, the lowest flower production at these growth stages was due to 100% defoliation (Table 4.6).

At 9 WAP, 50% defoliation resulted in the highest flower production while the lowest was due to 75% defoliation, but this difference was not significant (Table 4.6).

4.5.1.3 SAMNUT 23

There was no significant difference in flower number of variety SAMNUT 23 on each sampling date due to defoliation (Table 4.6).

At 6 WAP, 25 and 50% defoliation resulted in the highest flower production while the lowest was from the control (Table 4.6).

At 7 WAP, 100% defoliation resulted in the highest flower production while the lowest was due to 25 and 75% defoliation (Table 4.6).

At 8 and 9 WAP, the control resulted in the highest flower production. The lowest flower production at these growth stages was due to100% defoliation (Table 4.6).

At 10 WAP, the 25, 50 and 75% defoliation resulted in the highest flower production while the lowest was due to 100% defoliation (Table 4.6).

4.5.1.4 SAMNUT 24

At 6, 8 and 9 WAP, defoliation at 50% level produced the highest flower number while the lowest was due to 100% defoliation (Table 4.6).

At 7 and 10 WAP, 25% defoliation resulted in higher flower production while the lowest was due to 100% defoliation (Table 4.6).

4.5.1.5 Total flower

The data showed that in groundnut variety SAMNUT 21 the highest total flower count due to the control was only significantly higher than the lowest due to 100% defoliation. The data showed that, in groundnut variety SAMNUT 22 the highest total flower count was due to the control which not significantly higher than the lowest due to 100% defoliation. The 50% defoliation resulted in the highest total flower number in groundnut variety SAMNUT 23 which was not significantly higher than the lowest due to the control, 25 and 75% defoliation. In groundnut variety SAMNUT 24 the highest total flower due to 50% defoliation was comparable with that due to 25% defoliation. On the other hand, the lowest total flower count due to 100% defoliation was similar to that due to the control and 75% defoliation (Table 4.6).

Combined analysis of the data on flower production showed that, the highest flower production due to 50% defoliation was significantly higher than that due to 75 and 100% defoliation in groundnuts varieties. The combined analysis for varieties showed that, the highest flower production due to defoliation in SAMNUT 22 which was significantly higher than that of SAMNUT 23 and SAMNUT 24 (Table 4.7).

4.5.2 Matured pods

The highest number of matured pods at harvest was due to the 25% defoliation in varieties

Table 4.9: Combined analysis of the effect of defoliation on yield parameters of four groundnut cultivars

Defoliation level (%)	Flower Production/ plant	Total pods/plant	Matured pods/plant	Immature pods/plant	Pods weight (g)	Haulms weight (g)	Seeds weight (g)	Shelling percentage (g)	100-seed weight (g)
0	8.08a	20.17a	14.75a	5.58a	11.59ab	138.13a	7.41ab	65.83a	38.11a
25	8.00a	20.42a	15.92a	4.50a	12.21a	128.76a	8.05a	66.59a	39.52a
50	8.50a	19.00a	13.75a	5.25a	13.71a	157.36a	8.71a	64.38ab	37.99a
75	6.50b	18.17ab	12.50ab	5.67a	10.88ab	138.53a	6.62ab	60.61b	38.47a
100	5.75b	13.67b	8.83b	4.83a	8.50b	80.51a	5.67b	66.15a	38.29a
Variety									
SAMNUT 21	8.40a	23.00a	17.13a	5.87b	15.66a	167.82b	10.08a	64.64b	44.01a
SAMNUT 22	9.60a	23.20a	16.13a	7.07a	14.32a	221.75a	8.78a	61.43b	38.74b
SAMNUT 23	4.93c	11.67b	8.13b	3.53c	6.62b	52.05c	4.03c	61.67b	38.37b
SAMNUT 24	6.53b	15.27b	11.20b	4.20c	8.91b	73.01c	6.28b	71.12a	32.78c

Note: Means followed by the same letter(s) in each column, under each parameter and variety section are not significantly different (P = 0.05), using DMRT.

SAMNUT 21 and SAMNUT 24, the control and in SAMNUT 22 (Table 4.8). The lowest number of matured pods was due to 100% defoliation in varieties SAMNUT 21, SAMNUT 22 and SAMNUT 23(Table 4.8).

4.5.2.1 SAMNUT 21

At harvest, the highest number of matured pods in groundnut variety SAMNUT 21due to 25% defoliation was only significantly higher than the lowest due to 100% defoliation (Table 4.8).

4.5.2.2 SAMNUT 22

At harvest, the lowest number of matured pods in groundnut variety SAMNUT 22 due to 100% defoliation was only significantly lower than the highest control (Table 4.8).

4.5.2.3 SAMNUT 23

At harvest, the highest number of matured pods in groundnut variety SAMNUT 23 due to 50% defoliation was not significantly higher than the lowest due to 100% defoliation (Table 4.8).

4.5.2.4 SAMNUT 24

At harvest, the highest number of matured pods in groundnut variety SAMNUT 24 due to 25% defoliation was not significantly higher than the lowest due to 75% defoliation (Table 4.8).

The combined analysis on matured pods showed that, the highest number of matured pods due to 25% defoliation was only significantly higher than the lowest due to 100% defoliation. The combined analysis for varieties also revealed that, the highest number of matured pods due to defoliation was in SAMNUT 21 which was significantly higher than that due to SAMNUT 23 and SAMNUT 24 (Table 4.7).

Table 4.8 Effect of Defoliation on the Pods and Haulms yield (g) of four groundnut varieties.

Variety	Defoliation level (%)	Matured Pods/plant	Immature Pods/Plant	Total pods/plant	Haulms weight/plant
SAMNUT 21	0	15.33ab	4.67a	20.00ab	135.33ab
	25	26.00a	7.00a	33.000a	219.22a
	50	18.00ab	6.00a	24.00ab	203.57ab
	75	16.33ab	7.00a	23.33ab	193.45ab
	100	10.00b	4.67a	14.67b	87.50b
	Mean	17.13	5.87	23.00	167.82
	SE ±	3.86	0.92	4.62	36.36
SAMNUT 22	0	24.67a	10.67a	35.33a	319.05a
	25	14.00b	5.00c	19.00b	173.39bc
	50	15.67b	6.00bc	21.67b	243.12ab
	75	16.33b	8.00b	24.33b	240.48ab
	100	10.00b	5.67bc	15.67b	132.74c
	Mean	16.13	7.07	23.20	221.75
	SE ±	1.97	0.80	2.64	28.64
SAMNUT 23	0	8.33a	3.33a	11.67a	44.44a
	25	7.67a	2.67a	10.33a	39.63a
	50	10.00a	4.00a	14.00a	66.07a
	75	8.67a	3.67a	12.33a	62.50a
	100	6.00a	4.00a	10.00a	47.62a
	Mean	8.13	3.53	11.67	52.05
	SE ±	1.53	0.58	1.79	7.56
SAMNUT 24	0	10.67a	3.67a	13.67	53.70b
	25	16.00a	3.33a	19.33a	82.81ab
	50	11.33a	5.00a	16.33a	116.67a
	75	8.67a	4.00a	12.67a	57.69b
	100	9.33a	5.00a	14.67a	54.17b
	Mean	11.20	4.20	15.27	73.01
	SE ±	3.06	1.26	2.96	14.55
	Interaction:	Ns	S	S	S

Note: Means followed by the same letter(s) in each column, under each variety are not significantly different ($P \geq 0.05$), using DMRT. S= Significant, NS= Not Significant, WAP= Weeks After Planting

4.5.3 Immatured pods

At harvest, 50 and 100% defoliation resulted in the highest number of immatured pods in groundnut varieties SAMNUT 23 and SAMNUT 24. On the other hand, the lowest number of immatured pods due to 25% defoliation was obtained in SAMNUT 22, SAMNUT 23 and SAMNUT 24 varieties (Table 4.8).

4.5.3.1 SAMNUT 21

At harvest, the highest number of immatured pods per plant due to 25 and 75% defoliation in variety SAMNUT 21 was not significantly higher than the control (0%) and 100% defoliation (Table 4.8).

4.5.3.2 SAMNUT 22

At harvest, the lowest number of immatured pods per plant of groundnut variety SAMNUT 22 due to 25% defoliation was comparable to that of 50 and 100% defoliation. The highest number of immatured pods due to the control was significantly higher than that of the other defoliation (Table 4.8).

4.5.3.3 SAMNUT 23

At harvest, the highest number of immatured pods per plant in groundnut variety SAMNUT 23 due to 50 and 100% defoliation was not significantly ($P \geq 0.05$) higher than 25% defoliation (Table 4.8).

4.5.3.4 SAMNUT 24

At harvest, the highest number of immatured pods per plant in groundnut variety SAMNUT 24 due to 50 and 100% defoliation was not significantly higher than the lowest due to 25%

defoliation (Table 4.8).

The combined analysis of the data showed that, the highest number of immature pods due to 75% defoliation was not significantly higher than the lowest due to 25% defoliation (Table 4.7). The combined analysis for varieties showed that, the highest number of immatured pods due to defoliation in SAMNUT 22 which was significantly higher than that of the other groundnut cultivars (Table 4.7). The lowest immature pod number obtained for SAMNUT 23 was similar to that of SAMNUT 24.

4.5.4 Total number of pods harvested per plant

The highest total number of pod per plant was due to 25% defoliation in varieties SAMNUT 21 and SAMNUT 24. The lowest number of total pod per plant was due to 100% defoliation in varieties SAMNUT 21, SAMNUT 22 and SAMNUT 23 (Table 4.8).

4.5.4.1 SAMNUT 21

At harvest, the highest total pod number per plant obtained in SAMNUT 21 due to 25% defoliation was only significantly higher than the lowest due to 100% defoliation (Table 4.8).

4.5.4.2 SAMNUT 22

At harvest, the lowest total pod number per plant of groundnut variety SAMNUT 22 due to 100% defoliation was significantly lower than the highest due to the control (Table 4.8).

4.5.4.3 SAMNUT 23

At harvest, the highest total pod number per plant in groundnut variety SAMNUT 23 due to

50% defoliation was not significantly higher than the lowest due to 100% defoliation (Table 4.8).

4.5.4.4 SAMNUT 24

At harvest, the highest total pod number per plant in SAMNUT 24 due to 25% defoliation was not significantly higher than the lowest due to 75% defoliation (Table 4.8).

The combined analysis of the data showed that, the highest total number of pods per plant due to 25% defoliation was significantly higher than the lowest due to 100% defoliation. The combined analysis for varieties showed that the highest pod number per plant obtained in SAMNUT 22 was significantly higher than that due to SAMNUT 23 and SAMNUT 24 (Table 4.7).

4.5.5 Haulms

At harvest, the highest haulms weight due to 50% defoliation was in varieties SAMNUT 23 and SAMNUT 24. The lowest haulm weight of groundnut was due to 100% defoliation in variety SAMNUT 21, SAMNUT 22 and SAMNUT 24 (Table 4.8).

4.5.5.1 SAMNUT 21

At harvest, the highest haulms weight of groundnut variety SAMNUT 21 due to 25% defoliation was significantly higher than the lowest due to 100% defoliation (Table 4.8).

4.5.5.2 SAMNUT 22

At harvest, the highest haulms weight in SAMNUT 22 was similar to that due to 50% and 75% defoliation. On the other hand, the lowest haulms weight due to 100% defoliation was similar to that due to 25% defoliation (Table 4.8).

4.5.5.3 SAMNUT 23

At harvest, the highest haulms weight in SAMNUT 23 due to 50% defoliation was not

significantly higher than the lowest due to 25% defoliation (table 4.8).

4.5.5.4 SAMNUT 24

At harvest, the highest haulms weight in SAMNUT 24 due to 50% defoliation was similar to that due to 25% defoliation. The lowest haulms due to control was similar to that due to 25, 75 and 100% defoliation (Table 4.8).

The combined analysis of the data showed that, the highest haulms weight due to 25% defoliation was not significantly higher than the lowest due to 100% defoliation. The combined analysis of the data also showed that, the highest haulms weight in SAMNUT 22 was significantly higher than that of the other varieties. This was followed by that of SAMNUT 21. The lowest haulms in SAMNUT 23 was only similar to that of SAMNUT 24 (Table 4.7).

4.6 SEED YIELD

4.6.1 Pods dry weight

At harvest, the highest pods dry weight in groundnut variety SAMNUT 23 and SAMNUT 24 was due to 50% defoliation. The lowest pods weight was due 100% defoliation in varieties SAMNUT 21 and SAMNUT 22 (Table 4.9).

4.6.1.1 SAMNUT 21

At harvest, the highest pods dry weight of groundnuts variety SAMNUT 21 due to 25% defoliation was not significantly higher than the lowest due to 100% defoliation (Table 4.9).

4.6.1.2 SAMNUT 22

At harvest, the control had the highest pod dry weight in variety SAMNUT 22. This was followed with that due to 50 and 75% defoliation. The lowest due to 100% defoliation was

Table 4.9 Effect of Defoliation on Total Pods Dry Weight, Seed Weight, Shelling Percentage and 100-seed weight of four Groundnut Varieties.

Variety	Defoliation level (%)	Pod weight(g)	Seed Weight(g)	Shelling Percentage	100-seed Weight (g)
SAMNUT 21	0	13.50a	8.15a	61.77a	45.07a
	25	20.76a	13.06a	63.38a	44.74a
	50	17.55a	11.30a	64.26a	42.84a
	75	15.43a	10.29a	65.77a	42.75a
	100	11.06a	7.58a	68.00a	44.66a
	Mean	15.66	10.08	64.64	44.01
	SE ±	3.11	1.81	1.39	1.61
SAMNUT 22	0	20.78a	12.98a	62.35a	40.22a
	25	10.51c	6.55cd	62.16a	38.70a
	50	16.20b	9.63b	59.41a	36.23a
	75	14.68b	8.69bc	59.13a	37.64a
	100	9.42c	6.06d	64.12a	40.91a
	Mean	14.32	8.78	61.43	38.74
	SE ±	0.91	0.77	0.98	2.83
SAMNUT 23	0	5.34a	3.43a	64.11a	36.45a
	25	5.60a	3.79a	67.72a	40.75a
	50	8.41a	5.25a	59.97a	38.18a
	75	7.92a	4.18a	56.67a	42.37a
	100	5.86a	3.51a	59.86a	34.10a
	Mean	6.62	4.03	61.67	38.37
	SE ±	1.25	0.66	2.76	2.54
SAMNUT 24	0	6.76a	5.09ab	75.10a	30.68a
	25	11.97a	8.81a	73.10a	33.89a
	50	12.67a	8.67a	73.90a	34.74a
	75	5.50a	3.30b	60.87b	31.09a
	100	7.67a	5.52ab	72.63a	33.48a
	Mean	8.91	6.28	71.12	32.78
	SE ±	2.06	1.54	1.44	1.73
	Interaction: S		Ns	Ns	Ns

Note: Means followed by the same letter(s) in each column, under each variety are not significantly different ($P \geq 0.05$), using DMRT. S= Significant, NS= Not Significant, WAP= Weeks After Planting similar to that due to 25% defoliation (Table 4.9).

4.6.1.3 SAMNUT 23

At harvest, the highest pods dry weight due to 50% defoliation was not significantly higher (Table 4.9).

4.6.1.4 SAMNUT 24

At harvest, the highest pods weight of groundnut variety SAMNUT 24 due to 50% defoliation was not significantly higher than the lowest due to 75% defoliation (Table 4.9).

The combined analysis of the data showed that, the highest pod weight due to 50% defoliation was significantly higher than the lowest due to 100% defoliation. The combined analysis of the data also showed that, the highest pods weight obtained in SAMNUT 21 was not significantly higher than that of SAMNUT 22. The lowest pod weight observed in SAMNUT 23 was similar to that of SAMNUT 24 (Table 4.9).

4.6.2 Seeds weight

The highest seed weight/plant due to 25% defoliation was in variety SAMNUT 21 and SAMNUT 24. The lowest seed weight of groundnut in varieties SAMNUT 21 and SAMNUT 22 was due to 100% defoliation (Table 4.9).

4.6.2.1 SAMNUT 21

The highest seeds weight/plant of groundnut variety SAMNUT 21 due to 25% defoliation was not significantly higher than the lowest due 100% defoliation (Table 4.9).

4.6.2.2 SAMNUT 22

The highest seeds weight/plant was from the groundnut variety SAMNUT 22. This was followed by that due to 50 and 75% defoliation. The lowest seeds weight due to 100% defoliation was only similar to that due to 25% defoliation (Table 4.9).

4.6.2.3 SAMNUT 23

The lowest seeds weight/plant of groundnut variety SAMNUT 23 was not significantly lower than the highest due to 50% defoliation (Table 4.9).

4.6.2.4 SAMNUT 24

The highest seeds weight/plant of groundnut variety SAMNUT 24 due to 25% defoliation was only significantly higher than the lowest due to 75% defoliation (Table 4.9).

The combined analysis of the data showed that, the highest seeds weight due to 50% defoliation was only significantly higher than the lowest due to 100% defoliation. The combined analysis of the data also showed that, the highest seed weight observed in SAMNUT 21 which was not significantly higher than that due to SAMNUT 22 (Table 4.7). The lowest seed weight in SAMNUT 23 was significantly lower than that of the other varieties.

4.6.3 Shelling percentage

The data showed that, defoliation generally had no significant effect in shelling percentage in the four groundnut varieties. The 100% defoliation had the highest shelling percentage in groundnut varieties SAMNUT 21 and SAMNUT 22. On the other hand, the lowest shelling percentage was due to 75% defoliation in varieties SAMNUT 22, SAMNUT 23 and SAMNUT 24 (Table 4.9).

4.6.3.1 SAMNUT 21

The highest shelling percentage in variety SAMNUT 21 due to 100% defoliation was not significantly higher than the lowest due to the control (Table 4.9).

4.6.3.2 SAMNUT 22

The highest shelling percentage in variety SAMNUT 22 was due to 100% defoliation was not significantly higher than the lowest due to 75% defoliation (Table 4.9).

4.6.3.3 SAMNUT 23

The highest shelling percentage in groundnut variety SAMNUT 23 due to 25% defoliation was not significantly higher than the lowest due to 75% defoliation (Table 4.9).

4.6.3.4 SAMNUT 24

The highest shelling percentage in groundnut variety SAMNUT 24 due to the control was not significantly higher than the lowest due to 75% defoliation (Table 4.9).

The combined analysis of the data showed that, the highest shelling percentage due to 25% defoliation was significantly higher than the lowest due to 75% defoliation. The combined analysis of the data for varieties showed that, the lowest shelling percentage due to defoliation in SAMNUT 22 was significantly lower than the highest due to SAMNUT 24 (Table 4.7).

4.6.4 100-Seeds weight

The data showed that, leaf defoliation had no significant effect on 100-seed weight of the four groundnut varieties (Table 4.9).

4.6.4.1 SAMNUT 21

The highest 100-seeds weight from the control in variety SAMNUT 21 was not significantly higher than the lowest due to 75% defoliation (Table 4.9).

4.6.4.2 SAMNUT 22

The highest 100-seeds weight due to 100% defoliation treatment was not significantly higher than the lowest due to 50% defoliation (Table 4.9).

4.6.4.3 SAMNUT 23

The highest 100-seeds weight of groundnut variety SAMNUT 23 due to 75% defoliation was not significantly higher than the lowest due to 100% defoliation (Table 4.9)

4.6.4.4 SAMNUT 24

The highest 100-seeds weight of groundnut variety SAMNUT 24 due to 50% defoliation was not significantly higher than the lowest control (Table 4.9).

The combined analysis of the data for showed that, the highest 100-seed weight due to 25% defoliation was not significantly higher than the lowest due to 50% defoliation. The combined analysis of the data for varieties showed that, the highest 100-seed weight observed in SAMNUT 21 was significantly higher than that of the other varieties. The lowest 100-seed weight due to SAMNUT 24 was significantly lower than that of the other varieties (Table 4.7).

CHAPTER FIVE

5.0 DISCUSSION

Defoliation affect vegetative (plant height, shoot dry matter, root dry matter, root nodules and haulms) and yield (flower production, number of pods per plant, matured and immature pods, seed weight and 100-seed weight) parameters of groundnut in all the four varieties studied.

It was observed that the 75% defoliation resulted in the highest plant height in most cases. In groundnut variety SAMNUT 22 plant height decreased with increase in defoliation level at 4 and 7 WAP, but increased with increase in defoliation levels at 10 WAP. The result showed that, plant height increased in groundnut varieties with intensity of defoliation and being glaring especially at 10WAP. This increase in height could be as a result of more assimilates supplied to the tip meristem and leading to plant elongation. The defoliated plants have fewer branches compared to the non-defoliated but rather increased in height with intensity of defoliation. This is in agreement with the result obtained in peanut by Endan *et al*. (2006), who stated that, defoliation increased plant growth in peanut. However, this is contrary to the report of Ibrahim *et al.* (2010) which indicated that defoliation significantly reduced plant height, number of branches and crop growth rate, by defoliating at the vegetative and flowering stages in Cowpea, the decrease increased with increase in the intensity of defoliation.

Defoliation at 25 and 50% increased the root and shoot dry weight in groundnut varieties SAMNUT 22 and SAMNUT 23. This was probably due to increase in nutrient uptake by defoliated plants which may have increase in dry matter accumulation in mild defoliated plants. Decio and Flavio (1997) report that there was intense recovery of leaves by plants for low defoliation levels but complete defoliation reduced the speed of leaf area development in

soybean. They added that, severe defoliation may have extended the period of vegetative growth beyond the date it would normally stop growing.

Defoliation at higher levels reduced root and shoot dry matter and this was apparent in all the four varieties. For instance, the lowest shoot dry matter was observed at 100% defoliation in most cases. The reduction in root and shoot dry matter per plant due to defoliation was probably due to the removal of the photosynthetic apparatus which prevented the plants from accumulating dry matter. This result is in agreement with that of Ibrahim *et al*. (2010) who reported that, the effect of stages and intensity of defoliation on the vegetative characters prior to podding, suppressed the vegetative growth and altered partitioning in cowpea. Shibles *et al*. (1987) reported that, plants are affected by various manipulations that alter the source-sink ratio including depodding, partial or total shading of the foliage, foliage removal, light and carbon dioxide enrichment. Maposse and Nhempalele (2009) also reported that, there was linear decline in plant dry matter yield as defoliation intensity increased. Leaf removal may therefore, influence total dry matter production and yield through photosynthates production and distribution into different parts depending on the magnitude of leaf removal (Chauhan and Halima, 2003; Gustafson *et al*., 2006; Hossain *et al*., 2006).

Mild defoliation (25%) increased root nodules in varieties SAMNUT 22 and SAMNUT 23. This was probably due to more allocation of nutrients to the roots of defoliated plants since they have fewer branches and leaves, which was able to compensate the loss quickly in mild defoliated plants which lead to increase in nodules formation by mild defoliated plants. However, Whiteman (1970) stated that, defoliation reduced weight per nodules but the number of nodules increased per plant in both *Desmodium uncinatum* and *Phaseolus atropurpureus*. The reduction in roots nodules per plant at high defoliation level in all the four varieties could be probably due to reduction in initiation of new nodules which may have been affected by the

reduction of total assimilate that was translocated to the roots of plants. This result is in agreement with that of Osman *et al*. (1983) who reported that, defoliation reduced nodules formation and nitrogen fixation in 'Vaginia' and a 'Spanish' type peanut.

According to Karimi and Siddique relative growth rate (RGR) decreased with increase in defoliation level and with the age of the plants. This was probably due to decrease in growth by defoliated plants since photosynthetic apparatus have been removed and increase of shading of leaves canopy with age which lead to decreased in plant relative growth rate. Another reason could be that, crop growth increased rapidly to a peak between emergence and podding and then declined to zero just prior to pod maturity stage. Mild defoliation level seems to increase shoot and root RGR in most of the varieties. The 25 and 50% defoliation increased shoot and root RGR at age 4-7 and 7-10 WAP in groundnut varieties. This could be as a result of increase in nutrient uptake by mild defoliated plants which helped the plants to grow fast to compensate for the loss since the available leaves for nutrient distribution have reduced that could help the apical meristem and the remaining available leaves to have more nutrients which lead to increased in growth. The effect of defoliation on relative growth rate varies among varieties and this could be as a result of differences in developmental pattern and maturity between the varieties used in this study. Relative growth rate declined especially after 7 WAP, when there was sharp decline in relative growth rate in all the varieties. This is because at the initial stage of plant development the energy produced by existing leaves was distributed to few parts, but at the later stage when flower production has set in and pod setting was on, growth rate decreased so that more assimilates are used for flower production, pod setting and maturity. Similar result was obtained by Karimi and Siddique (1991) who reported that, relative growth rate declined throughout the growing season, and prior to pod maturity, RGR was negative in both old and modern Wheat cultivars.

General reduction in flower production in all the varieties due to defoliation was possibly due to the reduction in root and shoot growth particularly at high defoliation levels. Mondal *et al*. (2011) reported that defoliation reduced flower production resulting in lower pod and seed yield in Mungbean. They stated that, this could be due to lesser leaf area, inability to supply available assimilates to the sink and thereby flower abortion appeared higher in defoliated plants.

The increase in pod weight, seed weight and haulms weight in groundnut varieties was due to 25 and 50% defoliation levels. This must have been due to increases observed earlier in root and shoot dry weight and flower production at 25% and 50% defoliation levels. However, at higher defoliation levels (75 and 100%) a decrease was observed in pod weight, seed weight and haulms weight in these groundnut varieties. The reduction in number of matured pods per plant and increase in the number of immatured pods per plant due to defoliation in groundnut varieties could be attributed to reduction in root and shoot growth and flower production and delay in maturity observed in this study. This decrease in pods weight per plant was more pronounced when defoliation was complete (100 %). This reduction in weight of pods per plant could be due to the removal of leaves which reduced available leaf area for photosynthesis. Defoliation probably reduced the total assimilates supplied to the young pods. This result is in agreement with those obtained by Abdi *et al.* (2007); Mondal (2007); Barimanvandi *et al.* (2010) who reported that, the leaf is the major source of supplying assimilates to developing organs, young pods and seeds in crops. Mondal *et al.* (2011) reported that, defoliation not only reduced source size but also decreased total sink (flower) production resulting in lower pod and seed yield in Mungbean. Enyi (2008) also reported that, defoliation reduced dry weight of stem, pods, grains, and size of individual grain in all the four legumes crops studied. Enyi (2008) also

added that the adverse effect is more pronounce when defoliation was complete than when half of the number of leaves were removed.

The effect of defoliation on 100-seeds weight was not significant in each of the varieties. However, Maposse and Nhempalele (2009) reported that, pod number per plant, leaf protein concentration, grain yield and 100-seed weight were significantly reduced by defoliation in cowpea, 100-seed weight decreased linearly with increased in defoliation.

The shelling percentage increased with increase in defoliation in most cases. The 25% defoliation increased shelling percentage in groundnut variety SAMNUT 23. Mild defoliation seems to increase shelling percentage in variety SAMNUT 23. The shelling percentage increased linearly with increased in defoliation in groundnut variety SAMNUT 21. This could be that defoliation uniformly increased shelling percentage and as defoliation increases shelling percentage increased. This could be attributed to increase in immature pods observed by defoliation. This result is contrary to that obtained by Panchabhavi (1986) who reported that complete defoliation at different stages of growth reduced shelling percentage at all growth stages in groundnut variety ‘Dh8’.

The findings of this study revealed that defoliation affected both vegetative and yield parameters of the groundnut cultivars. Therefore, the null hypotheses which state that defoliation does not have effect on the vegetative growth and yield parameters of groundnut varieties should be rejected.

CHAPTER SIX

6.0 CONCLUSION AND SUMMARY

6.1 Conclusion

1. In conclusion, the impact of defoliation on vegetative parameters of groundnut cultivars varied among varieties and with the level of defoliation. The SAMNUT 23 was found to be more resistance to defoliation, followed by SAMNUT 24 and then SAMNUT 21 and SAMNUT 22 was the most affected in terms of vegetative parameters. At 25 and 50% defoliation levels there was increase in vegetative and yield parameters in groundnut.

2. The impact of defoliation on yield parameters of groundnut cultivars also varied among varieties and with the level of defoliation. The SAMNUT 23 was found to be more resistance to defoliation, followed by SAMNUT 24 and then SAMNUT 21 and SAMNUT 22 was the most affected in yield parameters. At 25 and 50% defoliation levels there was increase in vegetative and yield parameters in groundnut. Defoliation up to 25% was not detrimental to groundnut varieties but up to 75% and above reduced both vegetative and yield parameters.

6.2 Recommendations

Based on the result obtained, the following recommendations are put forward. Since defoliation of groundnut varieties up to 25% from below increased yield in groundnut, therefore, 25% defoliation of groundnut should not bother farmers since 25% defoliation maximize yield. Severe defoliation should be avoided in groundnut to ensure maximum yield. Further study should be carried out on the seeds from defoliated plants to see the effect of defoliation on the oil and nutrients contain of the seeds.

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APPENDIX

METEOROLOGICAL DATA

The meteorological data collected at institute for Agricultural Research, Samaru, Ahmadu Bello University, Zaria which included percentage Relative humidity, Air temperature, Wind speed, Sunshine and total Rainfall are presented in Appendix 1

Appendix 1: Samaru Daily Weather Report March to August, 2013

MONTH	DATE	% RELATIVE HUMIDITY 10 a.m	% RELATIVE HUMIDITY 4 p.m	AIR TEMPERATURE (0C) Max	AIR TEMPERATURE (0C) Min	SUNSHINE HOURS	WIND SPD (km/day) Average	TOTAL RAINFALL (mm)
3	1	48	9	40	23	8.1	118.38	
3	2	40	12	40	24	8.4	106.93	
3	3	33	10	40	21	7.5	125.39	
3	4	47	12	40	23	8.7	111.89	
3	5	39	17	40	24	8.7	115.34	
3	6	17	5	41	20	9.2	102.65	
3	7	26	5	41	22	9.1	118.17	
3	8	45	5	40	21	7.8	92.93	
3	9	41	7	41	19	6.8	110.19	
3	10	45	7	38	21	8.5	79.31	
3	11	25	9	39	21	7.5	112.11	
3	12	51	9	40	22	6.6	81.87	
3	13	44	16	39	22	7.7	95.21	
3	14	44	19	39	22	5	66.92	
3	15	13	21	41	22	5.4	103.96	
3	16	53	17	38	22	6.3	68.48	
3	17	11	26	39	21	7.7	94.9	
3	18	13	12	39	21	7.8	102.78	
3	19	9	7	40	22	8.9	111.12	
3	20	32	9	40	21	8.3	89.95	
3	21	9	12	39	21	8.3	118.43	
3	22	51	14	40	24	6.9	101.23	
3	23	48	14	39	23	6.4	110.08	
3	24	49	14	39	26	8.2	85.47	
3	25	46	34	40	25	7.8	123.1	
3	26	52	14	40	24	6.6	136.39	

3	27	53	14	40	26	7.6	159.66
3	28	50	22	37	26	5.3	191.58
3	29	55	26	37	25	9.3	228.04
3	30	43	28	34	26	6.8	249.69
3	31	50	27	38	26	9.2	153.36
4	1	50	24	40	24	9.2	121.2
4	2	40	24	40	24	8.8	134.42
4	3	53	25	40	25	8.8	165.74
4	4	41	27	39	27	6.6	107.2
4	5	46	23	40	23	9.2	122.8
4	6	53	28	41	28	8.3	165.22
4	7	50	27	40	27	5.2	169.28
4	8	58	24	38	24	6.4	155.07
4	9	57	26	36	26	4.2	202.53
4	10	52	25	38	25	7.8	151.28
4	11	49	25	40	25	8.4	102.51
4	12	42	25	40	25	9.4	118.06
4	13	55	25	39	25	4.9	104.31
4	14	50	25	38	25	6.6	119.56
4	15	50	25	38	25	9	114.34
4	16	49	25	39	25	6.8	139.26
4	17	58	27	35	27	4.8	209.74
4	18	55	25	39	25	7.7	158.73
4	19	47	26	35	26	6.9	174.32
4	20	66	22	33	22	1.6	129.08
4	21	62	23	35	23	3.7	169.7
4	22	67	23	30	23	6.3	121.2
4	23	61	24	35	24	6.4	128.51
4	24	58	25	37	25	7.5	103.99
4	25	87	24	34	24	6.2	110.23
4	26	26	23	39	23	9.7	173.94
4	27	20	26	39	26	8.1	199.37
4	28	68	23	33	23	8.4	134.64
4	29	55	24	36	24	8	122.75
4	30	63	25	38	25	7.7	161.97
5	1	71	44	37	24	9.3	204.76
5	2	55	44	38	25	9.4	183.92
5	3	60	39	37	26	6.9	206.82
5	4	67	45	33	27	8.6	189.99
5	5	46	63	38	24	7.8	199.74
5	6	77	41	36	27	5	167.07
5	7	62	53	37	24	8.2	233.5
5	8	64	48	34	26	4.9	210.85
5	9	67	51	35	23	6	162.53

5	10	65	49	37	26	8.7	174.38	
5	11	60	50	36	24	9.8	167.32	
5	12	62	48	37	25	8.4	119.78	
5	13	73	89	35	26	5	86.55	
5	14	68	53	36	25	7.4	164.05	
5	15	58	58	38	25	8.4	170.36	
5	16	58	46	38	25	9.3	177.79	
5	17	62	37	37	26	6.6	210.11	
5	18	63	48	36	25	8.2	173.63	
5	19	58	41	39	25	8.3	192.37	
5	20	64	44	37	27	8.6	235.48	
5	21	65	45	36	26	9	192.93	
5	22	71	54	34	22	8.1	248.58	
5	23	69	60	30	25	9.5	290.98	
5	24	55	57	36	23	8.1	245.08	
5	25	69	45	36	26	8.2	165.74	
5	26	66	50	30	25	5.7	140.45	
5	27	72	44	30	21	5.2	181.31	
5	28	76	62	32	25	7.1	208.86	
5	29	61	62	34	24	5.8	146.62	
5	30	71	48	33	25	8.4	200.95	
5	31	69	59	35	24	9.9	205.95	
6	1	63	53	33	25	9	173.51	
6	2	49	64	34	23	8.6	211.92	
6	3	68	58	34	23	SRS	279.63	
6	4	66	57	34	25		267.04	
6	5	68	57	31	23		208.44	4.5
6	6	72	56	31	23		191.19	
6	7	59	49	32	20		170.47	
6	8	54	55	33	25		235.53	
6	9	73	65	33	25		213.28	
6	10	76	63	34	23		161.08	
6	11	66	57	37	24		208.33	
6	12	68	50	33	24		255.23	
6	13	67	54	33	25		250.75	
6	14	78	48	33	22		193.57	
6	15	67	58	33	21		156.33	
6	16	57	61	35	23		176.47	
6	17	79	64	32	22		184.57	26
6	18	69	69	32	23		227.32	
6	19	74	65	33	24		282.15	1.7
6	20	69	58	33	23		240.93	
6	21	74	58	34	24		217.63	
6	22	63	53	29	25		199.64	

6	23	65	60	29	24		195.02	
6	24	68	67	29	23		155.02	
6	25	72	70	32	23		161.21	33
6	26	66	52	33	25		144.88	
6	27	83	64	32	22		156.83	8.6
6	28	88	66	28	22		152.03	
6	29	100	81	29	20		90.78	
6	30	68	74	38	22		127.53	
7	1	64	63	33	23		251.21	
7	2	75	68	31	22		165.82	
7	3	64	65	33	23		165.82	
7	4	70	64	32	23		162.42	4.4
7	5	77	53	31	21		121.53	
7	6	78	68	32	22		126.62	
7	7	85	68	27	21		155.41	12.5
7	8	81	86	30	22		109.75	
7	9	84	64	29	21		114.09	
7	10	81	60	31	20		131.02	
7	11	65	59	33	23		127.52	6.5
7	12	99	53	29	21		178.01	2.4
7	13	68	69	32	22		146.87	
7	14	78	68	31	23		164.04	
7	15	83	65	31	23		122.41	
7	16	79	65	31	25		193.06	
7	17	79	67	32	23	8.7	139.13	
7	18	86	70	29	21	6.4	149.39	
7	19	83	66	29	24	7.3	158.31	
7	20	88	73	28	21	3.8	104.28	
7	21	80	81	29	22	6.5	143.64	
7	22	76	70	32	24	1.7	141.12	
7	23	79	64	33	24	5.5	176.02	2.4
7	24	81	68	30	22	8.7	170.14	38.3
7	25	82	77	30	24	6.2	212.88	
7	26	79	65	29	20	4.6	201.59	
7	27	88	72	31	24	6.5	166.19	
7	28	98	62	28	23	0.8	193.06	
7	29	82	85	30	23	6.9	182.06	
7	30	92	71	31	24	2	192.88	
7	31	77	68	31	21	9.5	148.42	
8	1	81	62	30	24	5.7	195.08	
8	2	86	69	28	23	5.2	192.17	4.9
8	3	71	72	30	23	5.1	159.68	
8	4	87	67	31	23	7.8	149.2	23
8	5	86	66	26	23	4.5	211.5	

8	6	87	69	32	23	0	159.11	
8	7	79	86	30	23	6.7	177.76	
8	8	87	63	32	22	5.2	162.36	
8	9	80	68	30	23	1.1	148.93	
8	10	77	67	30	21	8.9	178.43	
8	11	89	69	30	20	2.6	189.59	7
8	12	78	72	28	20	4.7	128.7	7.4
8	13	86	69	30	22	1.3	141.7	
8	14	92	79	25	22	4.2	166.58	23.4
8	15	87	68	29	22	0.2	194.17	
8	16	85	81	30	23	4.2	146.93	
8	17	96	84	28	23	2.4	147.79	
8	18	83	77	32	22	1.8	77.24	
8	19	99	78	25	23	5.7	124.86	
8	20	86	72	28	22	1.9	108.08	
8	21	79	90	31	22	2.6	169.61	
8	22	81	81	30	23	7.4	144.39	
8	23	81	73	28	22	7.4	150.54	
8	24	77	71	30	24	0	134.42	15.7
8	25	86	75	29	20	6.3	99.95	29.6
8	26	85	75	31	23	3.5	78.38	56
8	27	85	75	31	23	6.9	70.19	
8	28	77	74	30	22	4.5	109.09	
8	29	79	72	30	23	6.6	174.58	
8	30	78	69	33	23	8.1	128.04	
8	31	78	62	30	23	7.2	130.82	

PLANTS HARVESTED

The number of plants/plot at harvest is presented in Appendix 2

Appendix 2: Number of plants at harvested.

Variety	Defoliation level (%)	Number of plants
SAMNUT 21	0	9.33a
	25	8.33ab
	50	7.00b
	75	7.33ab
	100	7.67ab
	Mean	7.93
	SE ±	0.60
SAMNUT 22	0	7.67a
	25	8.33a
	50	7.33a
	75	7.67a
	100	7.67a
	Mean	7.73
	SE ±	0.85
SAMNUT 23	0	9.67a
	25	9.33a
	50	7.33b
	75	7.33b
	100	7.33b
	Mean	8.20
	SE ±	0.30
SAMNUT 24	0	8.67a
	25	7.67ab
	50	6.00b
	75	9.00a
	100	7.67ab
	Mean	7.80
	SE ±	0.66

Table 4.1 Physical and chemical Parameters of the Soil used for the Experiment.

Soil Parameters	**Value**
pH in H_2O	6.90
pH in 0.01m$CaCl_2$	6.30
Organic carbon (%)	0.450
Percentage Available Phosphorus (ppm)	21.00
Total Nitrogen (%)	0.140
Exchange Bases (Cmol/kg)	
Ca	3.40
Mg	0.46
K	0.30
Na	0.42
H+Al	0.60
CaC	6.00
Particles sizes (%)	
Clay	12
Silt	18
Sand	70
Textured Class	Sandy – Loam.