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Effects of Nitrogen Application on Growth and Yield of Snowpeas *(Pisum sativum)*

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ABSTRACT

An experiment was conducted at Kabete field station, University of Nairobi between March and July 2000 (season I) and between June and September 2000 (season II) to determine the effect of different rates of nitrogen (N) fertilizer application on growth and yield of snowpea. Snowpea variety "Oregon sugar pod II" was used. The experiment was laid out in a complete randomized block design with three replicates. Four N levels (0, 50, 100 and 150 kg N ha-1) were split applied in equal halves as CAN (26% N) at 29 and 58 days after planting (DAP). Plant height, leaf area index, above ground dry mass, number of pods and pod dry weight were determined overtime. All the growth and yield parameters studied did not substantially benefit from N fertilizer application. It was therefore recommended that less N be applied for growth and yield of snowpeas.

INTRODUCTION

Nitrogen (N) influences the crop yields mainly through leaf area expansion, leaf area duration, and susceptibility to lodging (Addiscott *et al*., 1992). The growth rate and N composition of the new tissue determine demand for N by a plant.

The response of legumes to N application has been shown to depend on many factors among them its level. Lenka and SatPathy, (1976) reported that application of up to 40 kg N ha^{-1} increased vegetative growth, plant height and number of branches $plant^{-1}$ in pigeon pea. In beans, a low level of N fertilization of less than 50 kg N ha^{-1} was found to give early vigorous growth (Westermann *et al.,* 1981). Srivastava and Verma (1984) showed that application of 20 kg N ha^{-1} increased yields and quality traits in field pea (*Pisum sativum* L. var. arvense).

Gunawardena *et al.,* 1997 worked with different cultivars of pea and observed significant differences in shoot growth among cultivars but not between N levels. Nitrogen application did not affect root dry matter at any stage for any of the cultivars.

Increase in grain and shoot biomass in medium duration pigeonpea to N fertilizer applied at sowing on both Alfisols and Vertisols have been reported (Kumar *et al*., 1981). Nitrogen applied at later stages of growth i.e., from flowering onwards, boosted final dry matter and grain yield, particularly on Vertisols confirming the inadequacy of the symbiosis on this soil (ICRISAT, 1987). Lack of response to N on three other soil types, namely Alfisols, Entisols and Inceptisols in India may perhaps be due to high levels of N in the soil pool, or because N-fixation was adequate to meet the N requirements of the crop in these soils (ICRISAT, 1987).

In recent times, legumes are increasingly playing a central role in horticulture. In Kenya, much attention has been focussed on production of french beans (*Phaseolus vulgaris* L.) although production of snowpeas (*Pisum sativum*) is increasingly becoming important. Response of snowpeas to fertilizer N in Kenya has not been documented. The objective of this study was to determine the effect of different levels of N application on growth and yield of snowpeas.

MATERIALS AND METHODS

Snowpea (*Pisum sativum* var. Oregon sugar pod II), produced by Royal Sluis and treated with Thirum (class 3) was used in this experiment. The experiment was conducted in two seasons at Kabete field station, University of Nairobi between March and July 2000 (season I) and between June and September 2000 (season II). The site lies at latitude 1°15″S and longitude 36°44″E (Jaetzold and Schmidt, 1983) at an altitude of 1940m above sea level. The mean maximum and minimum temperatures are 23°C and 13°C respectively. The rainfall is bimodal, with long rains in March to June and short rains in October to December. The average rainfall is 1000 mm/year (Mburu, 1996).

The soils have been described as humic nitisols according to FAO/UNESCO (1984) classification, with Oxic paeleustult as the soils' taxonomy USDA (1975) equivalent (Siderius 1976). The soil pH ranges between 5.2 to 7.2 in the topsoil and 5.2 to 7.7 in the subsoil. Available potassium (K), calcium (Ca), magnesium (Mg), and phosphorous (P) ranges from low to fairly high levels. Total soil N is about 0.26 % (Njuguna, 1997). In this study, soil pH was determined using a pH meter, Soil N was determined by micro Kjeldahl method, soil available P was determined using mehlich's double acid method, CEC was determined using 1M KCL and 1M NH^{4+}Oac and organic carbon was determined using Walkley-Black method. Other soil parameters e.g. sand, silt and clay fractions, available Ca, Mg, Na and K were not determined. The results of soil analysis in the top 0-15cm before the experiment was conducted are shown in Table 3.

The treatments consisted of four N levels i.e. 0, 50, 100 and 150 kg N/ha applied as calcium ammonium nitrate (26% N). For each of the N rates, split application with half at 29 days after planting (DAP) and the rest at 58 DAP was adopted in both seasons to increase fertilizer N recovery by the crop. These rates were adopted based on the 100 kg N/ha applied to snowpeas by farmers. The experiment was laid out in a randomized complete block design. Each treatment was replicated 3 times. Each experimental plot measured 2 m x 3 m. The plant spacing was 0.1 m x 0.75 m within and between rows, respectively. Seeds were hand sown in furrows on 26th March 2000 in season I and on 3rd June 2000 in season II. In both seasons planted seeds took eight days to emerge.

The crop received 357 mm and 82 mm of rainfall in season I and season II, respectively. Supplemental sprinkler irrigation was done at 58 DAP (22nd May 2000) in season I. In season II, it was done after planting, at 29, 44 and 58 DAP (1st, 16th and 30th July 2000) respectively. In both seasons, each duration of irrigation was three hours and this supplied approximately 10mm of rainfall. The crop was trained 3 weeks after planting in both season in order to reduce lodging, improve air circulation around the plant, reduce incidence of pests and diseases and improve light penetration through the canopy. Crop training was done using sisal strings tied from 0.2 m to 1.2 m above ground at 0.07m to 0.1m intervals.

Weed control was done through manual cultivation. Two weedings were done before the canopy closed. Powdery mildew was controlled by alternate application of Antracol and Bavistin at 40g/15 l and 40g/20 l of water, respectively. Insect pests were controlled using Diazol at 30ml/15 l of water. All chemicals were applied at 10 to 14 day interval up to maturity.

MEASUREMENTS

Plant heights were measured at 31,38,45,58,71,84 and 97 DAP, on three plants randomly selected from the middle three rows using a meter rule. Leaf area index (LAI) was determined at 29, 43, 63, 77 and 94 DAP using the specific leaf area method (Norman and campbell, 1989). Using a cork borer, thirty 1-cm diameter discs were excised on 10 fully expanded leaves selected from three plants in each plot and put in 0.164m x 0.164m envelopes for drying. The remaining leaf portions were put in separate craft papers then oven dried (Model number TV80UL 508032, Memmert, Germany) to constant mass. The LAI was calculated using the following formula:

LAI = [LM x (LA discs /Lm discs)] x n (e.g. Mburu, 1996).

Where LM= leaf dry mass, LA discs = leaf area (m^2) of the discs, Lm discs = leaf dry mass (g) of the discs and n = number of plants per hectare.

Total above ground dry mass of snowpeas was determined on the three plants used for LAI determination. The leaves, leaf-discs, shoots and reproductive parts (pods, flowers and flower buds) were separately placed in craft papers and oven dried to constant mass. The snowpea pods were hand harvested from three plants randomly selected from three middle rows starting 68 DAP i.e. 1st June 2000 in season I and 9th Aug. 2000 in season II. Harvesting was done twice a week for upto five weeks by carefully picking the mature pods. Mature pods were described as being uniformly green, intact, clean (free from any disease or physiological disorders), flat with seeds not exceeding 4 mm in diameter and pod width of 1.5 to 2 cm (HCDA, 1996). The pods were then put in separate craft papers and oven dried after counting the number of pods.

STATISTICAL ANALYSIS

All the data collected was subjected to analysis of variance using GENSTAT 5 Release 3.2 statistical software (Lawes Agricultural Trust, Rothamsted Experimental Station, 1995). Treatment effects were analysed by fitting orthogonal polynomial contrasts at $P \leq 0.05$ (Steel and Torrie, 1981).

RESULTS

In both seasons, 50% flowering occurred at 58 DAP. Harvesting of pods started at 68 DAP and continued up to 100 DAP. The crop received 357 mm and 82 mm of rainfall in season I and season II, respectively. Nitrogen application did not affect plant height at all measurement durations in both experiments. On average the maximum plant height observed at the end of the experiment in both seasons was 0.86 m. There was no treatment effect on LAI at all measurement durations in both seasons (Figure 2). LAI increased up to 63 DAP and later declined. Influence of N application on total dry matter (TDM) at all measurement durations was not observed in both seasons (Figure 3). However at 43 DAP, TDM increased both linearly and quadratically in experiment II. TDM increased upto 77 DAP and decreased at 94 DAP in both seasons. Higher values of TDM were observed in season 1 than in season II.

Application of N did not affect number of pods plant^{-1} in most measurement durations in both seasons (Table 1). However, at 68 DAP in season I, number of pods plant^{-1} increased linearly with increasing N. In season II at 86 DAP, the increase in number of pods plant^{-1} was quadratic. Application of 50 kg N ha^{-1}resulted in the highest pod yield in both seasons. Pod production increased from 68 DAP up to 89 DAP, then decreased upto 100 DAP in both seasons. Pod production was high in season I than in season II. Overall, N treatment did not affect pod dry mass plant^{-1} at all measurement durations in both experiments (Table 2). However, pod dry mass increased linearly and quadratically with increasing N at 68 DAP in season I. A quadratic response was observed at 72 DAP in season II. At 86 DAP, both linear and quadratic increases were observed in season II.

DISCUSSION

The anticipated increase in growth and yield of snowpeas from N application was not observed in the present study. In season I, the crop was better supplied with water. However, high rainfall after 1st N application (146.1 mm) in three consecutive days may have leached some of the applied N. This can result in appreciable loss of topsoil nitrate and subsequent accumulation in the subsoil. Michori (1993) observed 2200 kg NO_3-N ha^{-1} at 1 to 5 m depth under fertilized coffee in Kenya. In season II, the total amount of water supplied to the crop between 58 and 100 DAP (Figure 1) was not more than 30 mm. This would result in restricted pea growth and also N uptake. Lack of increase in growth and yield following N application have been observed in soybean (Meyer *et al*., 1974) and in cowpea (Agboola, 1976). Exactly why N fertilizer did not affect growth in this study was not determined. Whether N affects growth of legumes depends on many factors including N fixation through symbiosis, soil N content, soil organic matter content and N uptake which is influenced by soil water supply.

Many legumes have been shown to satisfy their N needs through its fixation symbiotically with Rhizobia. For instance, Kumar (1980) estimated that pigeonpea could fix up to 69 kg N ha^{-1} per season, which accounted for 52 % of the total N uptake. Peas typically fix about 65 kg N ha^{-1} yr^{-1} with a range of 30 to 160 kg N hha^{-1} yr^{-1} (Tisdale *et al*., 1990). However, the amount of N fixed through symbiosis was not determined in this study.

It has been reported that response to N is highly probable only when total soil N is low i.e. less than 0.2% (Landon, 1991). Soil N at the study site was 0.24 and 0.26% in season I and season II, respectively hence medium (0.2 to 0.5%). Therefore, response to added N was expected. This shows that, lack of response to N application on growth of snowpeas, in this study may not have been due to soil N per se.

It has been reported that the level of soil organic matter affects crop response to applied N. Agboola, (1976) reported that on soils having 0.5% organic matter, grain yield of cowpeas was increased from 800 kg ha^{-1} on the check to 1850 kg ha^{-1} where 20 kg N ha^{-1} was applied. Although nutrient release from soil organic matter is normally more dependent on the portion of the organic matter in biologically active fractions than on total quantity of organic matter, he observed that in soils with 2% or more organic matter, there was no constant response to N fertilizer. The organic matter content in the soils of our study was 5.09% and 4.94% in experiment I and experiment II, respectively. It is therefore possible that, lack of response to N application may have been due to the high soil organic matter content.

In season II, there was increase in height with increase in N at 71 DAP and increase in TDM with increase in N at 43 DAP, respectively. This could be attributed to improved moisture availability following supplemental irrigation, which was done at 29, 44 and 58 DAP. Begg and Turner, (1976) reported that there is a significant interaction between N uptake and water stress. They also observed that there is a reduction in N uptake induced by water stress.

Leaf area index and above ground dry matter accumulation were higher in season I than in season II. Maximum LAI was observed at 63 DAP in both seasons but decreased more rapidly in season II than season I. i.e. at 94 DAP, LAI was 1.9 and 1.4 in seasons I and II, respectively. The variation in leaf growth between the seasons may imply that another factor other than N limited leaf growth and this was probably soil moisture availability. In Mexico, rainfall regimes were shown to exert a marked influence on maize N responses (Rockfeller foundation report, 1963-64). Lower responses to N were obtained when either excess moisture or drought occurred. Amount of rainfall received in season I was 357 mm compared with the 82 mm received in season II. Adequate soil moisture is important since uptake of mineral nutrients takes place via water films surrounding the soil particles. However, excess moisture may cause leaching of the N below the root zone thereby interfering with its availability for plant uptake. Consequently, in dry weather as in season II, N uptake may have been low due to impaired absorption.

Sheoran *et al*., (1981) reported that in pigeon peas, water deficit resulted in decreased water potential of the roots, nodules and leaves. This decreased water potential in the nodules resulted in decreased activities of nitrogenase, glutamine synthase, glutamate dehydrogenase and uricase, all of which are central in biological N fixation. Hence less N was obtained through symbiotic fixation in season II and this led to the observed low growth.

Dry mass accumulation in many legumes may affect yield via its influence on the rate of pod set, seed set and seed dry mass (Weber *et al*., 1966). Generally, leguminous crops do not respond by yield increases to soil or applied N to the same degree as other crops based on their ability to fix N. Paterson *et al*., 1966 reported significant effect of N fertilization on pod yield in snap beans. A similar observation has been reported in pigeonpea following application of urea at a rate of 30 and 45 kg N ha^{-1} (Mukindia, 1993). However, findings of the present study indicated that N application did not affect both the number of pods plant^{-1} and pod dry mass. Pietri *et al*., (1971) observed similar results in pigeonpea. This was attributed to lack of effect of N on number of branches plant^{-1}. It is not clear as to why pod yields in this study were not affected by N application. However, N may not have affected pod yield through its lack of effect on growth.

Reduction in yield can be brought about by a reduction in any of the yield components such as number of branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1} and 100 seed mass (Ishag, 1972). In this study, the decrease in yields in season II was attributed to decrease in number of pods plant^{-1} formed under moisture limiting conditions. This has also been reported in beans (Hidalgo, 1978) and in cowpeas (Turk and Hall, 1980). Decrease in pod number could be due to reduced flower production and increased flower abscission in dry weather (Turk and Hall, 1980). Sheoran et al., (1981) attributed the lack of response of yield of pigeonpea on low growth caused by water deficit. It is therefore suggested that low snowpeas yields were observed in season II due to the low soil water content. Snowpeas plants did not substantially benefit in growth from N fertilizer application. It is possible that either snowpeas were able to fix enough N to meet their requirements or these N requirements were met from the soil supply. This study shows that N application does not increase pea yields. Lack of increase in pea yield is attributed to lack of effect of N on growth. It has further shown that pea yields will be increased with high than low soil moisture.

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APPENDICES

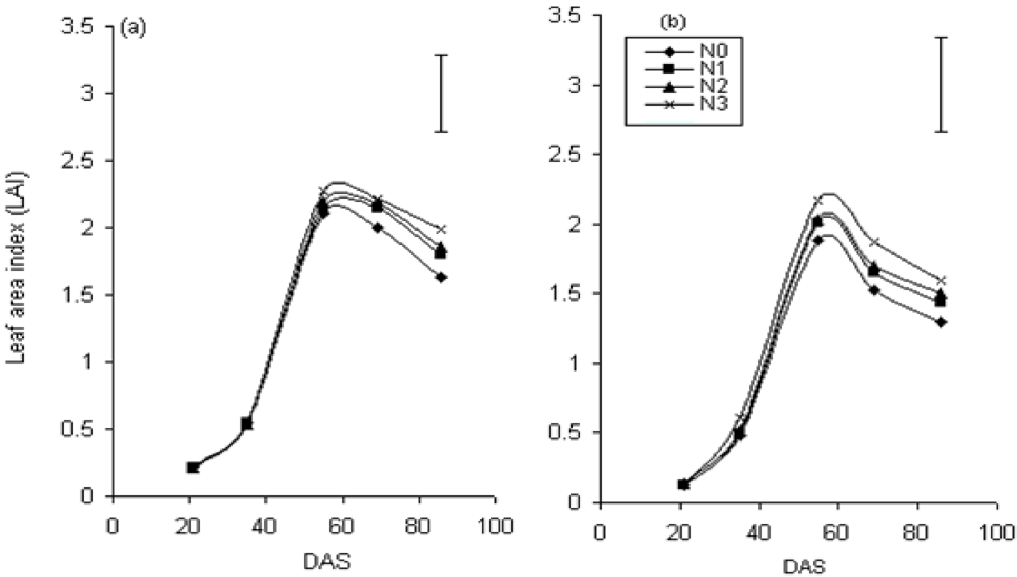

Figure 1. Effect of different levels of N on leaf area index (LAI) in snowpeas in season I (a) and season II (b) (DAS= Days after sowing, N0 = 0, N1 = 50,N2 = 100 and N3 = 150 kg N ha^{-1}, Vertical bars = Lsd bars at P = 0.05)

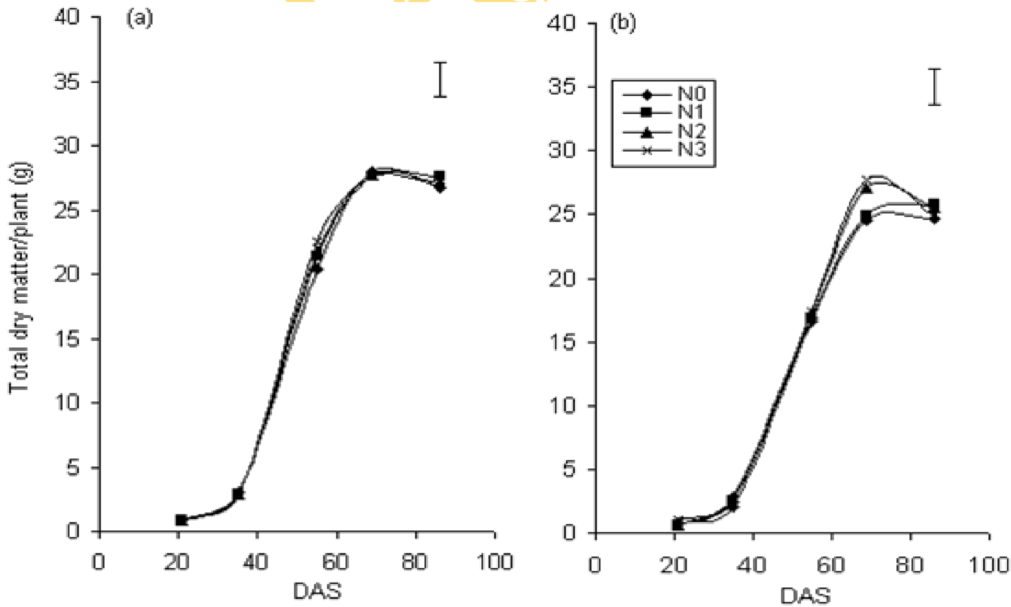

Figure 2. Effect of different levels of N on total above ground dry matter (AGDM) accumulation in snowpeas in season I (a) and season II (b), (DAS =Days after sowing, N0 = 0, N1 = 50, N2 = 100 and N3 = 150 kg N ha^{-1}, Vertical bars = Lsd bars at P = 0.05)

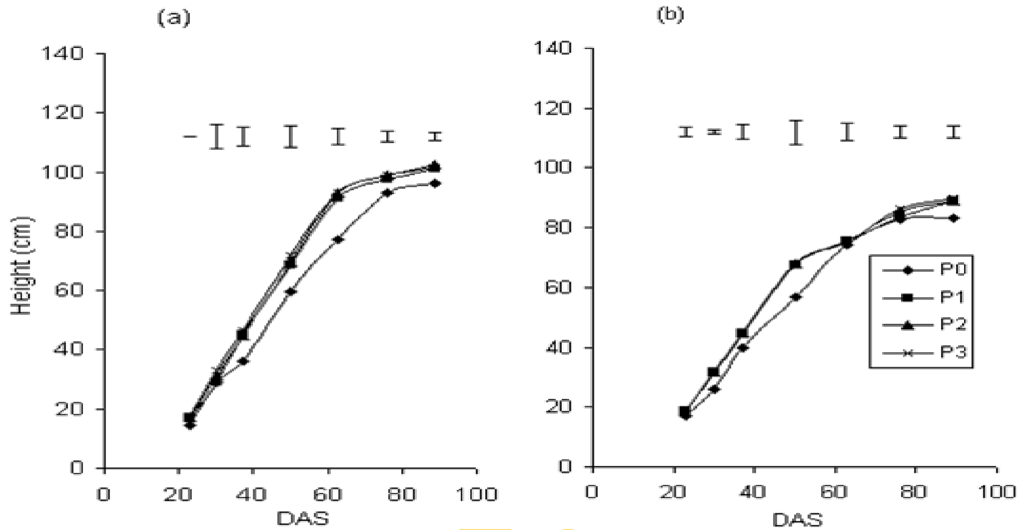

Figure 3. Effects of different levels of P on plant height in snowpeas in season 1 (a) and season 2 (b), (DAS= Days after sowing, P0= 0 , P1= 57,P2= 114 and P3= 171kg P_2O_5 ha^{-1},Vertical bars = Lsd bars at P = 0.05).

Table 1; Effect of different levels of N application on snowpeas number of pods $plant^{-1}$ in season 1(March-June 2000) and II (June-sept. 2000)

Season I	Days after planting										
N level	68	72	75	79	82	86	89	93	96	100	Total
N0	3.56	6.67	6.89	7.78	8.78	7.56	8.44	4.56	3.44	2.56	60.22
N1	4.33	6.44	8.11	8.44	8.33	8.11	7.89	4.22	3.44	2.56	61.89
N2	3.78	5.56	7.89	7.78	8.33	7.78	7.22	4.67	4.00	2.78	59.78
N3	5.00	6.89	7.44	8.33	7.67	7.00	8.22	4.11	3.11	2.56	60.33
Trend	L*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Season II											
N0	3.33	6.33	7.33	6.00	7.11	5.56	7.00	3.78	2.33	2.11	50.89
N1	3.22	5.11	6.67	6.78	7.89	6.67	6.00	4.89	3.11	2.44	52.78
N2	3.44	6.44	5.78	5.67	8.33	6.33	6.67	3.78	2.56	2.22	51.22
N3	3.33	6.33	7.33	6.00	7.11	5.56	7.00	3.78	2.33	2.11	50.89
Trend	NS	NS	NS	NS	Q*	NS	NS	NS	NS	NS	NS

N0, N1, N2, and N3 = 0, 50, 100, and 150 kg N ha^{-1}, NS= Not significant, *= Significant ($P \leq 0.05$), L = Linear, Q = Quadratic

Table 2: Effect of different levels of N application on snowpeas pod dry mass $plant^{-1}$ in season 1(March-June 2000) and II (June-sept. 2000)

Season I	Days after planting										
N level	68	72	75	79	82	86	89	93	96	100	Total
N0	0.96	1.62	1.68	1.88	2.11	1.85	2.05	1.14	0.83	0.62	14.74
N1	1.08	1.63	2.10	2.04	2.02	2.09	1.89	1.07	0.86	0.64	15.42
N2	0.95	1.36	1.92	1.88	2.02	1.91	1.77	1.14	0.95	0.68	14.58
N3	1.23	1.65	2.10	2.04	1.85	1.69	1.99	1.00	0.78	0.64	14.97
Trend	L*Q*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Season II											
N0	0.69	1.30	1.43	1.22	1.45	1.05	1.41	0.61	0.50	0.41	10.07
N1	0.68	1.07	1.37	1.38	1.60	1.37	1.25	1.02	0.67	0.53	10.94
N2	0.74	1.31	1.21	1.17	1.68	1.29	1.36	0.80	0.56	0.46	10.58
N3	0.69	1.30	1.48	1.26	1.47	1.17	1.57	0.79	0.46	0.45	10.64
Trend	NS	Q*	NS	NS	NS	L*Q*	NS	NS	NS	NS	NS

N0, N1, N2, and N3 = 0, 50, 100, and 150 kg N ha^{-1}, NS= Not significant, *= Significant ($P \leq 0.05$), L = Linear, Q = Quadratic

Table 3; Results of laboratory analysis of the soil from the experimental sites (0-15cm)

Parameter	Experiment 1	Experiment 2
pH (H_2O)	6.22	6.37
pH ($CaCl_2$)	5.36	5.39
%N	0.24	0.26
P (ppm)	17.9	18.7
%C	2.96	2.87
CEC (meq/100g)	14.3	14.1

pH (H_2O) = soil pH in water, pH ($CaCl_2$) = Soil pH in calcium chloride, %N = Percent nitrogen in the soil, P (ppm) = Soil phosphorous in parts per million , %C = soil organic carbon and CEC (meq/100g) = Cation exchange capacity.

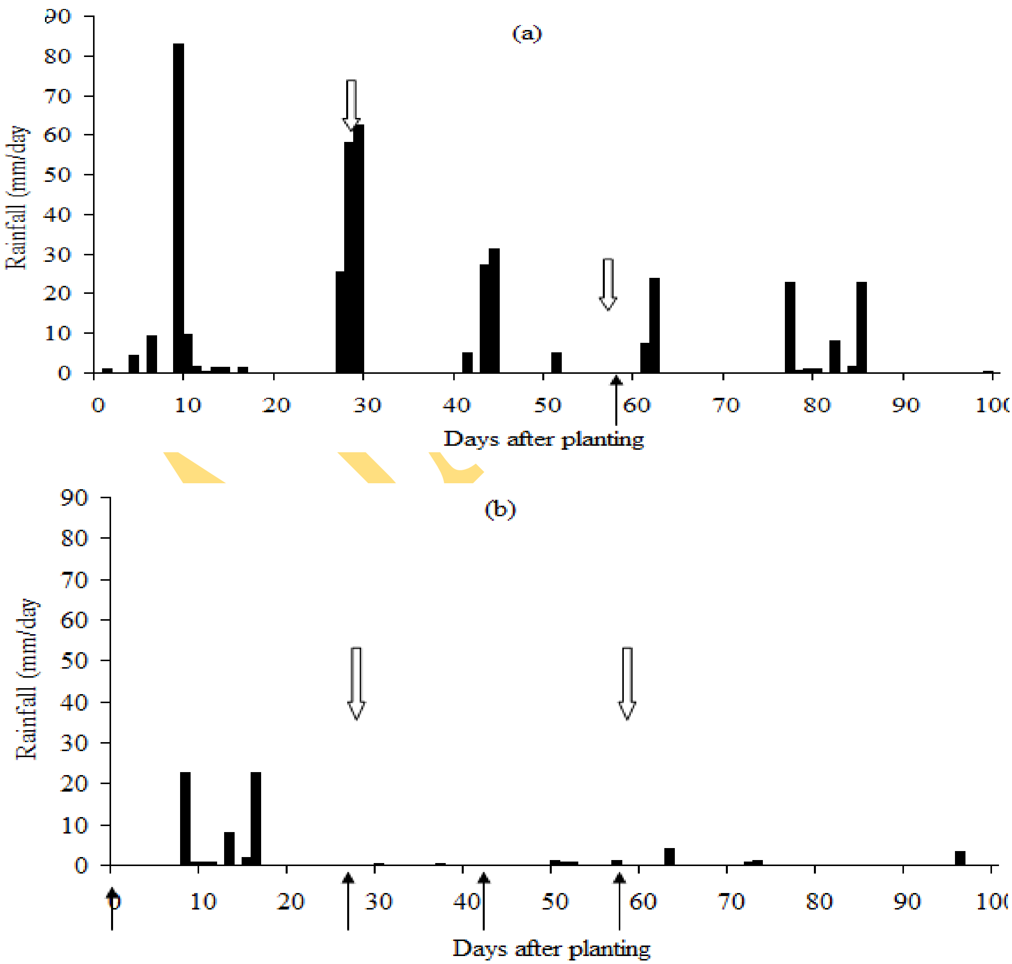

Figure 1: Daily rainfall (mm/day) in season I (a) and season II (b).
→ = Irrigation. Each irrigation supplied approximately 10mm of rainfall.
⇨ = Nitrogen application.

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