Effect of Nitrogen Rates on Leaf Quality of Two Cassava (Manihot Esculenta Crantz) Varieties as a Feed for Eri-Silkworm (Samia Cynthia Ricini Boisduval) Cocoon Production at Jimma, Southwest Ethiopia

Keywords: Nitrogen rates; Cassava leaf; Samia cynthia ricini; Biochemical composition; Cocoon traits

Abstract

Limited research efforts have been made on cassava leaf usage for rearing eri-silkworm in relation to nitrogen fertilizer management. Hence, field and laboratory experiments were conducted at Jimma University (Bio-dale Site) during 2016 with the objective of determining the effect of nitrogen on leaf quality and identifying appropriate cassava variety for better leaf quality as a feed for Eri-silkworm performance. A 2x5 factorial experiment arranged in Randomized Complete Block Design (RCBD) with three replications was used. The treatments consisted of two cassava varieties (Kello and Qulle) and five levels of N (0, 40, 80, 120 and 160 kg N ha⁻¹) as urea. For the laboratory experiment, to rear eri-silkworm, cassava leaves harvested from the field experiment (10 plots) were arranged in Completely Randomized Design (CRD) with three replications and their effect on Eri-silkworm performance assessed in terms of larval, cocoon, and post cocoon traits. Data were collected on growth attributes, leaf proximate analysis of cassava, eri-silkworm larval, and cocoon and post cocoon traits. Variety and nitrogen had variable in both laboratory and fields experiment including biochemical composition of leaves, Variety Kello was found to be superior compared to Qulle by revealing a silkworm rearing performance indicators of hatchability (90.23%), fecundity (366.2 eggs/female), shorter larval duration (18.46 days), better larval weight (6.27 gm), survival rate (92.66%), cocoon weight (3.44 gm), single shell weight (0.47 gm), pupal weight (2.96 gm) and effective rate of rearing (88%). Application of 160 kg N ha⁻¹ gave highest hatchability (93.85%), fecundity (384.83 eggs per female), larval weight (6.5 gm), shell weight (0.51 gm), cocoon weight (3.66 gm), pupal weight (3.15 gm) and shortest larval duration (17.333 days). In terms of biochemical composition, kello leaves had higher moisture content (30.012%), ash (18.541%) and crude fat (16.348%) and total carbohydrate (27.234%) were obtained from Qulle variety. 160 kg N ha⁻¹ gave the highest moisture (0.467%) and the lowest crude fiber (14.12%). The highest leaf nitrogen content (4.802%) and crude protein (30.012%) was gained from the combination of kello and 160 kg N ha⁻¹. In conclusion, variety Kello and 160 kg N ha⁻¹ can be used for higher leaf yield, leaf quality and cocoon yield.

Introduction

In Ethiopia, agricultural production is of a subsistence nature. The agricultural production system is mainly rain fed and traditional, which is characterized by low input of improved seeds, fertilizer, pesticides and other technologies [1]. Poverty and increasing population pressure led to decline in land holding per household that eventually resulted in low level of production to meet even the consumption requirement of the households [2]. Poverty reduction and Increases in the unemployment rate due to increases in the population, therefore, requires income generation activities like mass rearing of silk producing organisms to obtain silk [3].

More than 85% of the Ethiopian population, which resides in the rural area, is engaged in agricultural production as a major means of livelihood [4]. The Ethiopian government’s development policy emphasizes agricultural sector development led industrialization. In 1996, the government initiated a food security strategy built around, increasing agricultural production at the household level, ensuring access to food for food deficit households, and strengthening institutional emergency response capabilities to achieve food security [5,6].

Sericulture provides gainful employment, economic development and improvement in the quality of life to the people in rural area and therefore it plays an important role to meet this policy. It provides employment at various levels [7]. In his review of sericulture Industry in India classified the employment generation pattern of the industry into two major types: (i) Direct Employment - (a) Mulberry Cultivation; (b) Leaf Harvesting; (c) Silk Worm Rearing; (ii) Indirect Employment - (a) Reeling; (b) Twisting; (c) Weaving; (d) Printing & Dyeing; (e) Finishing; (f) Silk Waste Processing [8].

Sericulture is an agro-based industry. Sericulture provides economic development and improvement in the quality of life to the people in rural area and urban area in search of employment. It can make employment up to 11 persons for every kilogram of raw silk produced; out of which more than 6 persons are women [9]. Estimated that one hectare of mulberry creates employment of 13-16 persons per year and their location specific analysis indicated that for a production of one kilogram of raw silk, 11 man days are required which can, in turn, employ 30 man days for production of silk fabric. Showed that 96.36
man days of employment are generated from the establishment of one acre of mulberry garden for rearing 300 dfis (disease free layings) of silkworms in two months [10].

Historical evidence show that silk was discovered in China and from there it spread to other parts of the world. Silk is produced by the larvae from a variety of insects and spiders of the phylum Arthropoda. It is a natural protein fiber and is very soft, lustrous, smooth, strong and durable than any natural or artificial fiber [11]. Silkworm is a kind of insect which can produce silk solution. Insects mainly belong to two families, viz., Saturnidae and Bombycidae, which spins silk fibre [12]. Among saturniidae family S.c ricini is the one commercially exploited silkworm species and can be reared in doors throughout the year to produce silk [13,14]. Bombyx mori belongs to Bombycidae produces a delicate twin thread of silk fibroin, which is coated by a protective cover of sericin. Silk protein is a kind of protein like collagen, elastin, keratin, fibroin, sporgin etc., is an essential constituent of cocoon filament [15]. Reported that the silk fiber is almost a pure protein fiber composed of two types of proteins viz., sericin and fibroin [16].

Cassava, the most preferred food plant after castor has also been proved to be suitable for commercial rearing of silkworm. Cassava growers can divert a portion of foliage (25-40%) to raise eri silkworm and get extra income without affecting the tuber yield and starch content [17-19]. Also stated that cassava cultivation for eri silkworm rearing provides gainful employment to the women [20].

Eri silkworm is a domesticated multivoltine non-mulberry silkworm. It is a sericigenous insect exploited for its valuable eri silk. It is a multivoltine insect completing at least six to seven generations in a year and it can be reared throughout the year depending on the availability feed [14,21]. The agro-ecology and feed availability are the major requirements which have significant effect on rearing of larvae of this insect and finally cocoon crop yield and quality. It is a domesticated silkworm that feeds primarily on leaves of the castor plant. Eri-silkworm shows different rearing behavior when fed different food plants [22]. Eri-silkworm rearing also relies on management practices i.e., rearing temperature, humidity and nutrition. The healthier rearing conditions, environment and nutrition during larval period may lead to higher fecundity by silkworm moths [23,24].

The quality of feed plays a very important role for growth and development of the eri-silkworm and ultimately on the economic traits of cocoons. Leaf is a key factor besides environment and technology adoption for better growth and development of the silkworm larvae and cocoon production [25-27]. Reported that, among the various factors influencing silkworm growth and cocoon production, leaf quality plays a major role [28]. Eri- silkworm fed with more moisture, protein, sugar and carbohydrates and less minerals and crude fibre content is the best from the silkworm nutrition point of view [29].

Nitrogen application influences the quality of feed (leaf) especially its protein content [30,31]. As nitrogen is an important limiting factor for phytophagous insects, reduction of nitrogen contents has forceful effects on insect performances. The weights of larvae and cocoons of eri-silkworm are significantly influenced by nitrogen content of foliage [32]. Deficiencies in Nitrogen can also affect cassava yield in many ways. This might occur through reduction in leaf area, moderate reduction in photosynthetic rates of leaves, modification of branching habit and changes in the distribution patterns of dry matter to different plant parts [33].

Therefore, nitrogen application is very important for eri silkworm performance and cocoon production. In line with this, the present study was carried out with the general objective of evaluating performance of eri-silkworm reared on leaf of two cassava varieties cultivated under different rates of nitrogen application.

Materials and Methods

Description of the study area

The experiment was conducted at the experimental field in Jimma University College of Agriculture and Veterinary Medicine, Eladale Site, during 2015/2016 rainy season. It is about 365 km far from Addis Ababa on the road to Bedele. The research site is geographically located at 7° 42’ N latitude and 36° 50’ E longitude with an altitude of 1710 m above sea level. The dominant soils of the area are Nitisol and Cambisol. The area receives an average annual rainfall of 1530 mm. The area has an average maximum and minimum temperature of 26.2 °C and 11.3 °C, respectively and average maximum and minimum relative humidity of 91.40% and 37.92%, respectively [34].

Agriculture is the main occupation of the area and raising silkworm for eri cocoon production is not widely practiced but recently people in the study area are familiarized with silkworm production as a source of income.

Experimental materials and treatments

Two cassava varieties, namely Kello and Qulle, which were developed and released in 2005 by Hawassa Agricultural Research Centre, were used for this experiment. They were chosen for the study because of the fact that they have a wide range of adaptation and are high yielders and popular among farmers in the south and southwestern part of Ethiopia.

Eggs (seeds) of white plain 2.4 breed of eri-silkworm were used to study the effect of varieties and rates of nitrogen on eri-silkworms larval growth, cocoon and post cocoon characters. This type of eri-silkworm is hardy, disease resistant and can easily be reared [3].

The treatment consisted of factorial combinations of two cassava varieties (Kello and Qulle) and five different nitrogen rates (0,40,80,120 and 160 kg ha⁻¹) in the form of urea (46% N). Each level of nitrogen was combined with two levels of varieties. The national blanket fertilizer recommendation for cassava (80 kg N ha⁻¹) was used as a bench mark in the experiment.

Experimental designs

A. Field experiment: The field experiment to study the effect of nitrogen rates on leaf quality of two cassava varieties consisted of factorial combinations of two cassava varieties (Kello and Qulle) and five different nitrogen rates (0, 40, 80, 120 and 160 kg ha⁻¹) laid out in Randomized Complete Block Design forming 10 treatment combinations each replicated thrice. Gross plot size was 5m x 4m (20 m²) and the stem cuttings were planted at the spacing of 1m between rows and 1m between plants. There were five rows per a single plot.
The larval duration is the period between hatching and maturity of the larvae. Pairs of freshly emerged moth eggs were tested. The moths were decoupled after three hours and the female moths were allowed to lay eggs on the mountage. After beginning of hatching, the laying was counted to collect the data in respect to the total number of eggs laid per female moth, number of unfertilized eggs and number of hatched eggs per layings. The average hatchling of five layings was taken as representative hatchability percentage per layings in this case [45].

Data collected

Leaf proximate analysis: The leaf samples at three different heights of the plant viz., top, middle and bottom, were collected in paper bags at 180 days after stem planting and composite leaf samples were made. The dried leaf samples were ground into fine powder and well-maintained in butter paper bags for chemical analysis. Each sample had three replications. As adopted by [46], crude protein was estimated by multiplying the estimated value of the total nitrogen by 6.25, while the total nitrogen content of the leaf was determined by Kjeldahl method. Techniques and procedures of A.O.A.C. (2000) were used to determine crude fiber and crude fat contents [47]. The method of was used to estimate total minerals (ash) composition and total carbohydrates [48]. Accordingly, total carbohydrate was determined by the method of subtracting the percentage values of protein, fat, ash and fiber from 100.

Eri-silkworm characteristics: Grainage Parameters: Hatchability (%): After complete hatching (third day from the beginning of hatching) the laying was counted to collect the data in respect to the total number of eggs laid per female moth, number of unfertilized eggs and number of hatched eggs per layings. The average hatchling of five layings was taken as representative hatchability percentage per layings in this case [45].

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\text{Egg hatchability (lb)} = \frac{\text{Number of normal eggs} - \text{number of unfertilized eggs}}{\text{Number of normal eggs}} \times 100
\]

B. Fecundity (eggs/ female moth): Pairs of freshly emerged moth were placed on mountage and kept hanging on a wire. There were three replications of five pairs of moths in each replication for each treatment tested. The moths were decoupled after three hours and the female moths were allowed to lay eggs on the mountage. After three days, the eggs laid were separated from the mountage and counted replication wise to find out the fecundity and was recorded as numbers of egg per female.

Larval parameters

A. Larval duration (days): The larval duration is the period between hatching of eggs and maturity of the larvae and was recorded in each treatment replication wise in days.

B. Larval weight (gm): The weight of 5th instar larvae was taken when the larvae stopped eating; body became pale and excreted the last excreta. Five larvae were randomly picked from each treatment and weighed treatment and replication wise and their average was calculated.

C. Survival rate of larvae (%): This was measured by dividing the number of survived larvae by number of larvae brushed and expressed in terms of percent [45].
D. Effective rate of rearing (%): This is the number of larvae spinning cocoons out of the number of larvae brushed and is expressed in percentage [45].

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\text{Effective rate of rearing (\%) = } \frac{\text{Number of larvae survived}}{\text{Number of larvae brushed}} \times 100
\]

Cocoon parameters

A. Single cocoon weight (gm): On the sixth days of spinning, five cocoons were randomly harvested from each treatment and individual cocoon weight was weighted and their average was recorded [45].

B. Shell weight (gm): Randomly selected five cocoons were cut open, their pupae and larval exuviae were removed and average shell weight was recorded separately.

C. Pupal weight (gm): Similarly, after the cocoons were cut open, single pupa weight was recorded using sensitive balance. It can also be obtained by subtracting the shell and exuviae weight from the cocoon weight.

D. Shell ratio (%): The amount of silk present in a cocoon shell was expressed in percentage. It is weight of cocoon shell out of weight of the cocoon with pupa [39].
Data Analysis

All data collected on different parameters of proximate compositions of leaf, grain age, larval and cocoon parameters were first checked for normality and did not violate the rule. The data were subjected to analysis of variance (ANOVA) using SAS version 9.2 [49]. Significance differences between treatment means were delineated by LSD (Least Significance Difference) test at 5% level of significance.

Results and Discussion

Effect of Varieties and Nitrogen Rates and their Interaction on Leaf Proximate Composition of Cassava Varieties

A. Leaf moisture (%): Leaf moisture percentage of the two cassava varieties varied highly significantly with higher content being from Kello (43.8%) as compared to qulle (41.8%). Variation in moisture content between varieties could be attributable for their inherent characters. The increase in leaf moisture content might be enhancement in hydrogen ion concentration in plant sap due to accumulation of chlorides and less moisture loss by evapo-transpiration in the leaves [50]. These results are in conformity with the observations of [51], Sannappa and who observed variations in moisture content of leaves among castor genotypes [52].

From the result, application of different rates of N resulted in to highly significantly different (P<0.001) moisture content of the leaf.
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Table 5: Effects of varieties and nitrogen rates on cocoon parameters of eri-silkworm.

| Factors | SW (gm) | CW (gm) | PW (gm) | SR (%) | SW (gm) | CW(gm) | PW(gm) | SR (%) |
|---------|---------|---------|---------|--------|---------|--------|--------|--------|
| Varieties | | | | | | | | |
| Kello | 0.47<sup>a</sup> | 3.44<sup>a</sup> | 2.96<sup>a</sup> | 13.86<sup>a</sup> | 0.46<sup>a</sup> | 3.37<sup>a</sup> | 2.90<sup>a</sup> | 13.75<sup>a</sup> |
| Qulle | 0.46<sup>b</sup> | 3.32<sup>b</sup> | 2.86<sup>b</sup> | 13.86<sup>b</sup> | 0.43<sup>b</sup> | 3.2<sup>b</sup> | 2.76<sup>b</sup> | 13.71<sup>b</sup> |
| LSD (5%) | 0.01 | 0.01 | 0.001 | 0.22 | 0.01 | 0.04 | 0.04 | 0.44 |

Where: SW: Shell Weight; CW: Cocoon Weight; PW: Pupal Weight; SR: Silk Ratio; LSD: Least Significant Difference and CV: Coefficient of Variation. Means followed by the same letters within a column are not significantly different at 5% level.

**A. Crude fiber (%)**: The increase in N rates caused the decrease of crude fiber from 18.829% to 14.123%. The highest crude fiber of the leaf was documented at 0 kg N ha<sup>-1</sup> while the lowest crude fiber was observed at the highest (160 kg N ha<sup>-1</sup>) nitrogen fertilizer treatment. This shows that increasing N fertilizer rates decreased crude fiber in the leaf. The decline in crude fiber content with increased N rates could probably be attributed to the fact that plants tend to use more of their photosynthates on protein rather than carbohydrate synthesis. In case of varieties, there was notable variation between them. Qulle variety revealed higher crude fiber compared to Kello variety. The variation in crude fiber between the varieties may have occurred due to their inherent characters. This finding is supported by the finding of who recorded significant variation in crude fiber among castor genotypes [53]. Similar to this experiment, also observed variation in crude fiber in different castor genotypes [32].

**B. Crude fat (%)**: The increase in N rates caused the decrease of crude fat from 18.479% to 13.479%. The highest crude fat in the cassava leaf (18.496%) was registered at the rates of 120 kg N ha<sup>-1</sup> application. Crude fat which includes all lipids, chlorophyll, carotenes and all other fat soluble material tends to be enhanced by N application [56]. The least crude fat content (13.437%) was recorded with no application of N (0 kg ha<sup>-1</sup>). Crude fat content between two castor varieties varied highly significantly with higher content being from kello as compared to qulle (Table 1). Variation in crude fat content between varieties could be attributable for their difference in terms of their inherent characters. Consistent with the current findings, findings of observed variation in fat content among castor genotypes [32,57].

**C. Ash (%):** In case of ash content, higher ash content was estimated from the leaves of kello (18.541%) variety. The main reason for variation in ash content between the varieties could be due to genetic factors (Table 1). Observed significant variation in ash content between eight different castor genotypes [53]. Ash content may also vary due to variation in metal composition in the same plant of different variety [54]. On the other hand, application of different rates of N highly significantly (P<0.001) influenced ash content of the leaf per plant. Ash content of the leaf increased gradually with the increase in the rates of N. The leaf with highest ash content (19.17%) were recorded at the rates of 80 kg N ha<sup>-1</sup> while least leaf ash content (15.435%) was recorded with no N application (0 kg N ha<sup>-1</sup>). This low ash content is indicative of the low mineral content of cassava [55].

**D. Crude fat (%):** The increase in nitrogen caused an increase in crude fat of leaf. The highest crude fat in the cassava leaf (18.496%) was registered at the rates of 120 kg N ha<sup>-1</sup> application. Crude fat which includes all lipids, chlorophyll, carotenes and all other fat soluble material tends to be enhanced by N application [56]. The least crude fat content (13.437%) was recorded with no application of N (0 kg ha<sup>-1</sup>). Crude fat content between two cassava varieties varied highly significantly with higher content being from kello as compared to qulle (Table 1). Variation in crude fat content between varieties could be attributable for their difference in terms of their inherent characters. Consistent with the current findings, findings of observed variation in fat content among castor genotypes [32,57].

**E. Total carbohydrate (%):** The total carbohydrate which is analyzed on dry weight basis as a difference of the sum of ash, crude protein, crude fat and crude fiber from 100 also revealed significant variation for different rates of nitrogen and two cassava varieties. Qulle recorded higher carbohydrate content of 27.234% while Kello registered 22.797%. The difference in total carbohydrate content between the two varieties might be attributed to the variation in genetic factors. The present observation is in agreement with the findings of and who detected variation in the total carbohydrate content among castor genotypes [58-60]. With regard to N, the highest total carbohydrate was gained from application of 80 kg N ha<sup>-1</sup>. Limited N supply results in higher level of carbohydrates [61,56]. The lowest total carbohydrate was obtained from the highest application of N (160 kg/ ha<sup>-1</sup>).
From the interaction point of view, the leaf results to better growth of the larvae leading to health moth composistion which has been shown above under the section on hatchability could be due to the variation in floral nutrient attainment from qulle variety. The possible reason for the difference in hatchability was gained from kello variety while the lower was obtained from qule with no application of N (Table 2). Leaf nitrogen content ranged between 3.403% and 4.657%. There was also variation between two cassava varieties. Kello had higher nitrogen content in its leaf than Quelle. This result is in agreement with the findings of who observed significant difference among castor genotypes in terms of nitrogen content [32,62,63]. In the same manner, also recorded different amount of nitrogen from different varieties of castor [64].

G. Crude protein (%): From the interaction point of view, the highest leaf crude protein (30.012%) was recorded from kello variety with the application of 160 kg N ha⁻¹ while the lowest leaf nitrogen content was obtained from qule with no application of N (Table 2). Higher crude protein content was higher for Kello variety. The variation in the crude protein content between the two varieties may at least partly be attributed to genetic factor. Recorded variation in crude protein content among castor genotypes [51,52,58-60].

Crude protein which is 6.25 times the nitrogen content (Lord, 1968) varied markedly among different rates of nitrogen. The lowest crude protein was gained from no application of nitrogen (0 kg N ha⁻¹) whereas the highest crude protein was obtained from the application of the highest nitrogen (160 kg N ha⁻¹). The possible reason for the increment of protein content as the application of nitrogen increase could be due to the fact that N is utilized to synthesize amino acids, which in turn form proteins [30,31].

Effect of Varieties and Nitrogen Rates on the Rearing Performance of Eri-silkworm

Grainage parameters: Significant differences were observed in grainage parameters of eri-silkworms when fed with cassava leaves of two varieties grown on different rates of nitrogen fertilizers (Table 3). A. Hatchability (%): During first and second rearing, the highest hatchability was observed from application of 160 kg N ha⁻¹ which was statistically similar with application of 120 kg N ha⁻¹ in the first cycle of rearing while the lowest was recorded from no application of nitrogen (0 kg N ha⁻¹). The probable reason for the increment of hatchability could be due to the increase of leaf nitrogen. The reduction of hatchability during second cycle might be due to the reduction of nutrients in the leaf, in most case, was matured/aged.

In case of varietal impact on eggs hatchability, the higher hatchability was gained from kello variety while the lower was attained form qule variety. The possible reason for the difference on hatchability could be due to the variation in floral nutrient composition which has been shown above under the section proximate composition analysis. Better nutrient composition of the leaf results to better growth of the larvae leading to health moth and eggs produced from such moth hatches normally. The present result is corroborated with the observations of who found variation in hatchability due to the castor genotypes when used for rearing eri-silkworm [65-68].

B. Fecundity (eggs/ female moth): Both first and second cycle of rearing indicated that higher fecundity was recorded from kello variety when compared to qule variety. The variation in fecundity during first and second cycle with two cassava varieties may be due to the differences in foliar compositions which contribute to the growth and development of silk worms. This is confirmed by the findings of who observed variation in fecundity between different castor genotypes [69,70].

N application significantly influenced the fecundity of eri-silkworm moth. Fewer egg numbers were recorded from the control treatment while the highest fecundity was obtained from the application of 160 kg N ha⁻¹ (Table 3). Fecundity increased as nitrogen level increased. The reduction of fecundity during second cycle might be due to the reduction of nutrients in the leaf as the leaf matured.

Larval parameters

Significant differences were observed in larval parameters of eri-silkworms between the two varieties and different rates of nitrogen in both rearing cycles except for survival rate of the larvae and effective rate of rearing to different rates of nitrogen (Table 4).

A. Larval duration (days): The longest larval duration was recorded from zero application of N (0 kg/ha) which was not statistically different from 40 kg/ha nitrogen fertilizer rate. The shortest larval duration was recorded at 160 kg N ha⁻¹. This showed that larval duration decreased with increase in N fertilizer. Observed negative correlation of nitrogen with larval duration.

Significantly shorter total larval duration was recorded in the larvae fed on Kello variety in rearing cycles, 18.47 and 19.67, respectively. The possible reason for the variation observed in larval duration between the two varieties might be due to their nutritional difference. Better nutrient compositions in the leaves result in to fast growth of the worms and reduce larval duration. Similar results were obtained by who reported that different castor varieties fed to silkworms exhibited differences in larval duration [66,68].

B. Matured larval weight (gm): Larval weight varied very significantly in two cassava varieties. Kello registered higher matured larval weight than Quelle in both rearing cycles (Table 4). The variation in matured larval weight of silkworm fed with two cassava varieties might be due to nutrional difference of leaves which contribute to the growth and development of silkworms. The characters of cocoon primarily depend upon the larval weight. The result of matured larval weight indicated that the feed had significant effect on them. Larval weight can vary depending upon the feed plants which the larvae feed [57,71]. These authors observed differences in larval weight when eri worms were fed with leaves of different castor genotypes.

Different rates of N application resulted in to significant differences in larval weight. The lowest larval weight was registered from the control treatment while the highest larval weight was obtained from the application of 160 N kg ha⁻¹ which is statistically similar with application of 120 kg N ha⁻¹ (Table 4). The highly nutritious and nutrient balanced food is the main factor responsible for healthy growth and development of any insect. Larval weight increased as nitrogen rate increased.

C. Survival rate (%): The analysis of variance for survival rate
showed that this trait was not influenced statistically by rates of N (P <0.05) (Table 4).

Varieties showed significant variation on survival rate of eri-silkworm. Survival rate of eri-silkworm was higher for Kello when compared to Quelle (Table 4). The study was in line with the work of who found significant differences in survival rate of eri-silkworms when fed on different castor varieties [65,72].

D. Effective rate of rearing (%): Effective rate of rearing showed significantly different when eri-silkworm fed on two cassava varieties in both rearing cycles (Table 4). Eri-silkworm fed on Kello recorded higher effective rate of rearing than Quelle. Difference in effective rate of rearing was observed among castor genotypes used as feed by earlier workers [67,68,73-75].

The nitrogen rates didn’t affect the effective rates of rearing. The reduction of effective rate of rearing during second cycle might be due to the reduction of nutrients in the leaf.

Cocoon parameters: Cocoon parameters of eri-silkworm (shell weight, cocoon weight and pupal weight) showed significant variations when larvae were fed with two cassava varieties applied with different rates of nitrogen. But, the two varieties during both cycles of rearing and different rates of nitrogen during second cycle of rearing did not show significant differences for silk ratio (Table 5).

A. Single cocoon weight (gm): Significant differences were observed in single cocoon weight of larvae fed with the leaves of two cassava varieties. Significant differences were observed in single cocoon weight of larvae fed with the leaves of two cassava varieties grown with different rates of nitrogen in both cycles of rearing (Table 5). Cocoon weight is the most important character for productivity of silk farming [76]. During first and second cycles of rearing, application at 160 kg N ha⁻¹ resulted in to significantly higher cocoon weight (3.66 gm and 3.496 gm). The lowest was obtained at no application of Nitrogen. The weights of cocoons are significantly influenced by nitrogen content of foliage [32].

Higher cocoon weight was recorded from Kello variety when compared to Quelle. This result is in agreement with the finding of who reported that cocoon weight depends on the type of hosts provided for feeding the larvae [77]. The occurrence of higher values of single cocoon weight on the feed plants of these two cassava varieties in the present study might be due to their higher larval weight gain at the end of the larval feeding period.

B. Shell weight (gm): It is evident that varieties of cassava had significant effect on shell weight of the silkworm during first and second cycle of rearing. Shell weight was found to be significantly higher in Kello as compared to Quelle. This finding is comparable with the reports of who opined that the shell weight varied with the type of hosts provided at the larval stage [65]. Also reported that shell weight varied when eri-silkworms were reared on different varieties of cassava leaves [71].

Different rates of Nitrogen application resulted in to differences in shell weight of eri-silkworms (Table 5). The highest shell weight was recorded from application of 160 kg N ha⁻¹ although it was not statistically different from application of 120 kg N ha⁻¹. The lowest was recorded from no application of nitrogen (0 kgN ha⁻¹). The probable reason for the increment of shell weight as the rates of N increased could be due to the fact that N is considered as one of the nutrients in the leaf which highly contributes for the growth of larvae and then better shell weight. The reduction of shell weight in the second rearing cycle might be due to the reduction in nutritional status of leaf.

C. Pupal weight (gm): Pupal weight differed significantly between two cassava varieties during both cycles of rearing. During both rearing cycles, the higher pupal weight (2.96, 2.86 gm) was registered from Kello variety when compared to Quelle (2.90, 2.76 gm). The result of pupal weight depends on result of cocoon weight and shell weight. This result is in conformity with the findings of who reported that pupal weight depends on the type of hosts provided for feeding the worms [51,65,72,78-80].

The highest N application, 160 kg N ha⁻¹, resulted into biggest pupal weight and the smallest pupal weight was recorded from no application of nitrogen (0 kg N ha⁻¹) (Table 5). The highest values of pupal weight from the highest application of N might be due to highest larval weight gain at the end of the larval feeding period [81-85].

D. Silk ratio (%): Silk ratio of eri-silkworm is highly significantly (p<0.001) affected by nitrogen fertilizer rates during both rearing cycles (Table 5). During first rearing cycle, the highest silk ratio was obtained from 120 kg N ha⁻¹ which was not statistically different from the application of 80 kg N ha⁻¹. The lowest silk ratio was recorded from no application of nitrogen (0 kg/ha⁻¹) which didn’t differ statistically from 40 kg N ha⁻¹. During second rearing cycle, the effect of fertilizer did not result in statistically significant (P <0.05) difference for this parameter (Table 5) [86-89].

There was no variation between varieties for both rearing cycles. This result contradicts with results obtained by who reported that castor varieties were different in silk ratio [65,66,68,90-95].

Conclusion and Recommendation

The results of analysis of variance revealed significant differences in biochemical composition and rearing performance of silk worms. It was found that varieties and rates of nitrogen showed highly significant influences on mineral and nutrient content of leaf and eri-silkworm grainage, larval and cocoon yield parameters. Variety Kello produced higher value for plant leaf nutrient contents (moisture, ash and crude fat), grainage, larval and cocoon parameters (hatchability, fecundity, larval weight, survival rate, effective rate or rearing, cocoon weight, shell weight, pupal weight and silk ratio), while Quelle variety bettered on crude fiber, total carbohydrate and larval duration.

N application at 160 kg N ha⁻¹ resulted to maximum value for proximate composition of the leaf (moisture), and for eri-silkworm parameters (hatchability, fecundity, larval weight, single cocoon weight, shell weight, pupal weight and shell ratio). The highest values for crude fiber and total carbohydrate were recorded from no application of urea. Combined application of 160 kg N ha⁻¹ and use of Kello cassava variety showed higher mean number for nitrogen and crude protein. The least record in all parameters was from the control treatment except for crude fiber and carbohydrate.
In conclusion, cassava can grow well in the study area and farmers can benefit more by using the application of 160 kg N ha⁻¹ which resulted in maximum leaf yield, leaf quality and cocoon productivity and the variety kello which is more productive in terms of leaf quality and cocoon productivity.

However, more research should also be carried out to support the current findings in the following areas:

1. Amount and frequency of leaf defoliation should be studied.
2. Appropriate integration of eri silkworm rearing with cassava tuber production.
3. Other nutrients and minerals in the leaf should further be explored in that they have relationship with rearing performance of eri-silkworm.
4. Cost benefit analysis should be done.
5. Similar experiments are suggested to be carried out at different seasons and different locations because repetition of the experiment for more seasons and locations would help us to draw sound conclusions and recommendation.

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