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Assessment of the Combination of Two Selected Mulberry Varieties (Morus Alba), S14 and S30 as Compared with Single Variety Fed to Silkworm (Bombyx Mori L.) on the Insect Performance

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Abstract:
The influence of different mulberry varieties on silkworm performance has been investigated in various studies. However, scanty information is available on the effect of combination of mulberry variety to feed the insect on the insect performance. Therefore, this study was conducted to investigate the influence of combination of two selected mulberry varieties (S14 and S30) of mulberry leaves as against feeding the insects with one of the varieties on its performance. Silkworm eggs (EJ2 × EC1) were incubated for 10 days and newly hatched larvae were brushed, fed with mulberry leaves and reared following the standard protocol. The worms were separated into replicates of 100 worms/tray at the end of 1st moulting. The rearing trays were laid in Randomized Complete Block Design with 5 treatments replicated 4 times where the treatments were S14, S30, S14(75%) + S30(25%), S14(50%) + S30(50%), S14(25%) + S30(75%). The worms were later mounted on chandrike at the completion of their larval stage for cocoon spinning and the spurn cocoon were harvested 5 days after mounting. The result of the study showed that highest larval weight was obtained when the worms were fed with the combination of mulberry varieties S14 (50%) + S30(50%) (2.24±0.08) at P≤0.05 however the worms fed with only variety S30 all through produced the best results in terms of single cocoon weight, pupal weight, shell weight, total cocoon weight, number of cocoon formed and number of days to cocooning. This implies that mixture of different mulberry varieties to fed silkworm should be discouraged.

Keyword: *Silkworm performance, silkworm eggs, mulberry varieties, chandrike, larval weight*

1. Introduction

The rearing of silkworm (Bombyx mori L.) in order to get silk has being an age-long and land-based practice discovered by man over 5000 years back in China, its place of origin. Nowadays, the domestic silkworm provides probably more than 99% of the silk world-wide with the highest being produced in China followed by India (Vijayprakash and Dandin, 2005).

Silkworm is one of the most important domesticated insects which produce luxuriant silk thread in the form of cocoon by consuming mulberry leaves (Morus alba) during larval period. In India, there has being a high employment potential and economic benefit from this practice especially to agrarian families. Sericulture has been able to provide gainful employment for millions of people with an indirect effect of about 25% of farm income in India (Mattigatti and Iyengar, 1995).

Owing to its glittering luster, softness, elegance, durability and tensile properties, silk is called queen of textiles (Rahmathulla, 2012). Silk is a functional term used to describe natural-protein fibres that are secreted by arthropods (Chowdhary, 2006). This natural silk is preferred to other kind of fibre due to its remarkable properties like water absorbency, heat resistance, dyeing efficiency and luster. Silk fibre is one of the most beneficial insects to mankind and is becoming an alternative multifunctional material for both textile and non-textile uses (Tsukada et al., 2005) and almost all commercial silk is made from cocoon spun by silkworm of the genus Bombyx (Lee, 1999). The silk is found useful in production of fibrics, aeroplane tyres, bullet-proof materials, parachute and stitching materials. The pupal stage of the insect also contributes to human diet being an edible insect, in Korea, silkworm is used to make a dish known as Bondaegi.

Man has immensely benefited from the silk produced by silkworms and subsequently researchers have always been trying to unveil the factors that can be manipulated to benefit the silkworm rearers (Nair and Kumar, 2004). The biological as well as cocoon-related characters are influenced by ambient temperature, rearing seasons, quality mulberry leaf and genetic constitution of silkworm strains. Nutrition plays an important role in improving the growth and development of B. mori (Kanafi et al., 2007) and nutritional intake has direct impact on the overall genetic traits such as larval and cocoon weight, amount of silk production, pupation and reproductive traits.

The success of cocoon crop has often been said to mainly depend upon three major factors viz quality of laying, quality of leaves used and which type of rearing method is adopted by the farmer (Chandrappa et al., 2001; Shekharappa, 1991; Laxmanan et al., 1998).

Eight mulberry varieties (S54, S41, S36, S34, S30, S14, K2 and NG1) were introduced to Forestry Research Institute of Nigeria (FRIN), Ibadan, between 1984 and 1999 (Ashiru, 2000), these varieties have been assessed on how they affect the performance of the silkworm but knowledge on the influence of combination of two or more of these varieties on the insect performance is lacking, hence, the need for this study. Therefore, this study aims at investigating the influence of combination of two different varieties (S14 and S30) of mulberry leaves as against feeding the insect with just one of the varieties on the insect performance.

2. Material and Methods

The experiment was conducted at Entomology Section of department of Forest Conservation and Protection, Forestry Research Institute of Nigeria. Forestry Research Institute of Nigeria (FRIN), Jericho, Ibadan, South-West Nigeria is located between longitude 30.53' and 30.9'E and between latitude 70.25' and 70.55'N. The annual temperature ranges between 18.07 ℃ and 34.4 ℃. The region is characterized with bimodal pattern of rainfall with peaks in July and September with mean annual rainfall of 1420.106 mm. The mean relative humidity was 82% between June and September and 60% between December and February (Ugwu and Ojo, 2015).

The silkworm eggs (EJ2 x EC1) were procured from the Ekiti Sericulture Project, Ado-Ekiti. The mulberry varieties selected were S14 and S30 (these two being the best two among the eight varieties available on the field according to Ashiru's report) from FRIN mulberry plantation. The mulberry leaves were harvested from the plantation in the morning for the feeding of the insects.

Prior rearing, the rearing room and equipments were properly washed and disinfected. The procured eggs were incubated for 10 days and after hatching the larvae were brushed from the egg cards into well prepared rearing trays. Succulent and nutritious leaves cut into approximately 1cm x 1cm size were fed to the newly brushed larvae, at rate of 30g/dfl, 90g/dfl, 500g/dfl, 1000g/dfl and 8000g/dfl at 1st, 2nd, 3rd, 4th and 5th instar larval respectively per day following Badejo *et al*. (2009) recommendation. The insects were fed thrice a day (8am, 12 noon and 4pm) (Adeduntan, 2004). The size of the cutting was increased with the age of the insect until the insects were able to feed on the whole leaves.

The two mulberry varieties (S14 and S30) investigated in this study were mixed at different proportions to feed the worms as stated in the treatments below. At the end of 1st moulting, the worms were distributed into their replications at 100 worms per tray and bed cleaning was carried out at the end of each moulting. The rearing trays were laid in Randomized Complete Block Design (RCBD) with 5 treatments replicated 4 times where the treatments were as follow. S14; S30; S14(75%) + S30(25%); S14(50%) + S30(50%) and S14(25%) + S30(75%).

At the completion of the insect larval stage, the worms were hand-picked and mounted on chandrike and the spurn cocoons were harvested 5 days after mounting.

The two selected mulberry varieties (S14 and S30) used in this study were harvested from FRIN mulberry plantation and subjected to proximate analysis at the Department of Animal Science Laboratory of University of Ibadan, Ibadan, Nigeria.

Data were collected on parameters like, 5th instar larval weight, number of insect mounted, single cocoon weight, shell weight, pupal weight, total cocoon weight, number of cocoon formed and effective rate of rearing (ERR) and shell ratio (SR) using the formula below.

$$ERR = \frac{no\ of\ larval\ spinning\ cocoon}{no\ of\ larva\ brushed} \times 100 \qquad SR = \frac{shell\ weight}{cocoon\ weight} \times 100$$

Data collected were subjected to analysis of variation (ANOVA) using SAS software package and means were separated using Duncan New Multiple Range Test.

3. Results

From table 1 above, the combination of mulberry varieties S14 and S30 fed to the insects significantly affected their larval weight. However, the highest larval weight was obtained from insects in trays with combination of equal quantity of S14 and S30 (2.24±0.08g) followed by the ones fed with only S14 (1.86±0.07g) while the least was from trays with fed with combination of S14 (25%) + S30 (75%) (1.63±0.04g) at $P<0.05$.

The effect of this varietal combination was also significantly felt in the single cocoon weight. The single cocoon weight was significantly highest in trays with worms fed with only S30 (1.25±0.03g) closely followed by the ones from trays fed with the

combination of S14 (25%) + S30 (75%) (1.15±0.04g) P<0.05. The single cocoon weight was lowest in trays where the worms were fed with combination of S14 (75%) + S30 (25%) (0.98±0.03g).

Silkworm pupal weight was significantly highest in trays with worms fed with only S30 mulberry variety (1.04±0.02g) followed by the ones fed with the combination of S14 (25%) + S30 (75%) (0.95±0.1g), meanwhile, the single pupal weight from other treatments were not significantly different from one another P<0.05.

In terms of shell weight, with the exclusion of the worms fed with combination of S14 (75%) + S30 (25%), there was no significant difference among other treatments.

Although the highest total cocoon weight was significantly highest in the trays containing worms fed with only S30 (65.96±1.75g) however this was not significantly different from the ones containing worms fed with the combination of S14 (50%) and S30(50%) (52.83±3.95g). The lowest total cocoon weight was from worms fed with combination of S14 (75%) + S30 (25%) (38.68±8.29g) P<0.05.

Treatment	Larval weight (g)	Single cocoon weight (g)	Pupal weight (g)	Shell weight (g)	Total cocoon weight (g)
S14	1.86 ± 0.07^{b}	1.04 ± 0.01^{cd}	0.86 ± 0.03^{c}	0.16 ± 0.02^{ab}	44.63 ± 4.66^{bc}
S30	1.81 ± 0.10^{bc}	1.25 ± 0.03^{a}	1.04 ± 0.02^{a}	0.21 ± 0.04^{a}	65.96 ± 1.75^{a}
S14 (25%) + S30 (75%)	1.63 ± 0.04^{c}	1.15 ± 0.04^{b}	0.95 ± 0.01^{b}	0.21 ± 0.04^{a}	44.82 ± 1.56^{bc}
S14 (50%) + S30 (50%)	2.24 ± 0.08^{a}	1.09 ± 0.03^{abc}	0.93 ± 0.02^{bc}	0.16 ± 0.02^{ab}	52.83 ± 3.95^{ab}
S14 (75%) + S30 (25%)	1.8 ± 0.07^{bc}	0.98 ± 0.03^{d}	0.89 ± 0.02^{bc}	0.09 ± 0.02^{b}	38.68 ± 8.29^{c}

Table 1: Effect of Combination of Two Mulberry Varieties (S14 And S30) Fed To Bombyx Mori on Larval Weight and Cocoon Traits
Means with the Same Alphabet Are Not Significantly Different

Across all the treatments, the highest number of insects mounted was obtained from the combination of S14 (75%) + S30 (25%) fed trays (96.5±1.5), this was not however significantly different from other treatments except the ones fed with S30 (Table 2). The highest number of cocoon formed was from trays fed with only S30 mulberry varieties (81.0±3.72) followed by the ones from trays fed with the combination of S14 (75%) + S30 (25%) (58.75±10.06) P<0.05.

The number of days it took the worms to form cocoon was not significantly influenced by feeding the with combination of these two mulberry varieties (S14 and S30) however, it was highest in insects fed with the combination of S14 (75%) + S30 (25%) (26 days) and lowest in insects fed with only S30 (24 days) P<0.05

Treatment	No of insect mounted	No of cocoon formed	Days to cocooning
S14	91.25 ± 2.06^{ab}	65.0 ± 4.55^{ab}	25.25 ± 0.48^{ab}
S30	89.0 ± 2.35^{b}	81.0 ± 3.72^{a}	24.5 ± 0.29^{b}
S14 (25%) + S30 (75%)	90.75 ± 3.71^{ab}	71.75 ± 5.11^{ab}	25.25 ± 0.25^{ab}
S14 (50%) + S30 (50%)	96.25 ± 1.38^{ab}	77.0 ± 5.93^{ab}	25.25 ± 0.25^{ab}
S14 (75%) + S30 (25%)	96.5 ± 1.5^{a}	58.75 ± 10.06^{a}	26.0 ± 0.58^{a}

Table 2: Effect of Combination of Two Mulberry Varieties (S14 And S30) Fed to Bombyx Mori on Number of Insect Mounted, Number of Cocoon Formed and Days to Cocooning
Means with the Same Alphabet Are Not Significantly Different

In the present investigation, the shell ratio was highest in the cocoon produced by worms fed with the combination of varieties S14 (25%) + S30 (75%) 17.76% followed by the one from the worms fed with S30 16.78% while the lowest was from the ones fed with the combination of S14 (75%) + S30 (25%) 9.27% (Table 3).

Also, the effective rate of rearing across the treatments was statistically variable and ranged between 89-96.5%. The highest was obtained when the insects were fed with combination of mulberry variety S14 (75%) + S30 (25%) while it was lowest in worms fed with variety S30 alone.

Treatment	Shell ratio (SR) (%)	Effective Rate Rearing (ERR) (%)
S14	15.64	91.25
S30	16.78	89
S14 (25%) + S30 (75%)	17.76	90.75
S14 (50%) + S30 (50%)	14.85	96.25
S14 (75%) + S30 (25%)	9.27	96.5

Table 3: Effect of Combination of Two Mulberry Varieties (S14 And S30) Fed to Bombyx Mori on Shell Ratio and Effective Rate of Rearing

The proximate analysis of the two selected mulberry varieties S14 and S30 used in this study showed that percentages of the crude protein, crude fibre, ash content, dry matter, nitrogen and potassium are higher in variety S30 than in S14 (Table 4).

Mulberry leaf variety	% Crude protein	%Crude fibre	% Ether extract	% Ash content	%Dry matter	%N	%P	%K
S14	26.59	11.65	3.38	13.0	12.5	4.266	0.34	0.838
S30	27.45	12.35	2.65	19.28	15.7	4.368	0.315	0.850

Table 4: Proximate Analysis of Mulberry Varieties S14 and S30

4. Discussion

From this present study, silkworm 5th instar larval weight was significantly influenced by the combination of these two varieties and was highest in worms fed with variety S14 (50%) + S30 (50%). This could be due to the fact that the worms were able to get the best nutrient equally from the two varieties good enough for proper growth and development at 50:50 proportion. It is important to state that silkworm growth is often associated with the accumulation of organic matter resulting from the balance between both the anabolic and catabolic reaction spurned by the nutritive substances absorbed after digestion of food. This probably could have been achieved at best level with the equal combination of these varieties to feed the worm hence reason for this significant larval weight. This is further corroborated by the report of Ramesha et al. (2010) that the nutritional requirement in food consumption of silkworm have direct impact on all genetic traits like larval weight, cocoon weight, quantity of silk production, pupation and reproductive traits.

Furthermore, the combination of these mulberry varieties did not produce better result on the insects as single cocoon weight, pupal weight, shell weight and total cocoon weight (1.25±0.03g, 1.04±0.02g, 0.21±0.04g and 65.96±1.75g respectively) were significantly highest in trays where the worms were fed only with mulberry variety S30. This suggests that variety S30 singly has a better influence on these cocoon traits owing to a better nutritional value it has compared to S14 as proximate analysis reflects (Table 4) and when combined with another variety. This is however contrary to the earlier report of Ashiru (2000) that silkworm performed better with mulberry variety S14 than others. Furthermore, this subsequently is in consonance with the report of Bahar et al. (2011) that says that in order to obtain good cocoon harvest, selection of leaves for feeding silkworm larvae should be qualitative according to age of the larvae and should not be a mixture of different varieties.

From table 2, although the number of the worms mounted on chandrike was lower in trays where the worms were fed with only variety S30 however, this did not have negative effect on the number of cocoon formed when compared with those from other treatments as the highest number was recorded in trays where the insects were fed with only S30. It is established that silk protein produced in the silk gland of Bombyx mori is mostly synthesized from the amino acids present in the mulberry leaf proteins. Therefore, this result implies that the worms were able to utilize the nutrients for cocoon formation more and without any contamination or nutritional obstruction when worms were fed with S30 than when fed with other variety or combination of varieties. This could also be attributed to nutrient superiority of variety S30 to others (Table 4).

The short duration of 24 days of cocooning recorded in worms fed with only mulberry variety S30 implies that the insect was able to utilize the necessary nutrients needed for cocoon spinning more from it than in S14 or combination of others. This can still be said to be due to its superlative nutritional value (Table 4) and this is in line with report of Kherdeker et al. (2000) that high leaf quality has been identified as a pre-requisite for healthy silkworm growth and high-quality cocoons. In addition, Adeduntan (2015) earlier reported that it takes 25 days for silkworm to spin cocoon. This present study however shows that feeding silkworm with high quality mulberry leaves without combination with other can reduce this duration by a day

Shell ratio has often been said to be one of the economic indices of silkworm. From this present investigation, the shell ratio was highest when the worms were fed with combination of mulberry varieties S14 (25%) and S30 (75%) and closely followed by S30 with no significant difference. It can be inferred from this that good shell quality can still be obtained from silkworm when fed only with S30 than when fed with S14 or in combination with any other variety. The effective rate of rearing in this study ranged from 89% to 96%. The effective rate of rearing is an important parameter for judging mulberry variety in respect of rearing performance (Radhakrishnan and Periasamy 1986). This ERR indicates an encouraging rearing

performance from the insect when subjected to single mulberry variety feeding (S14 or S30) or combination of these varieties in different proportion.

In general, silkworm is known to derive the necessary nutrients required for their growth, development and for cocoon formation from mulberry leaves. To this end, various studies are being conducted on how to improve the nutrition of the insect for a more profitable return. From this present study, the end result shows that the worms when fed with only S30 all through produced the best results in terms of single cocoon weight, pupal weight, shell weight, total cocoon weight, number of cocoon formed and number of days to cocooning than S14 or when in combination with each other. This is in agreement with earlier report that the performance of the insect is best when they are not fed with mixture of mulberry varieties. Therefore, mixture of mulberry varieties to feed silkworm should be discouraged in order to run sericulture as a profitable venture.

5. References

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