Vol. 2 December 2011
CHED Accredited Research Journal, Category A
Print ISSN 2094-5019 • Electronic ISSN 2244-0461
doi: http://dx.doi.org/10.7828/ajob.v2i1.98

Asian Journal of Biodiversity
Art. #98, pp. 183-208

Hybridization and Genetic Improvement of Mulberry Varieties

CRESTILYN N. DAMASCO
MERLITA A. DACAYANAN
LILIA A. ANCHETA
MENIRVA J. TABAFUNDA
ROEL D. SUPSUP
CRISTETA F. GAPUZ
Don Mariano Marcos Memorial State University

Date Submitted: June 21, 2011
Final Revision Accepted: June 28, 2011

Abstract - This research focused on the evaluation of Open Pollinated Varieties (OPVs) for sprouting and rooting characters growth, yield and quality for effective utilization in crop improvement for sustained mulberry biodiversity. The OPVs Alf-004, Alf018, Alf-028, S61-019, S54-019 and the Batac variety were set up in Randomized Complete Block Design with three replications. The four year pooled data were analyzed using the Analysis of Variance across season and DMRT for further test of significance. Correlation analysis was used to determine the association among yield related characters. Number of branches per plant (NoB), length of longest shoot (LLS), plant height (PH), moisture content (MC) and moisture retention capacity (MRC). Propagation characters as to sprouting percentage (s), rooting percent ®, fresh weight of roots (FWR), fresh weight of shoots (FWS), length of roots (LR), length of shoots (LS), root to shoot ratio by weight (RSR wt), root to shoot ratio by length (RSR L) and number of root (NoR) were considered. Results revealed that the best performing mulberry OPVs based on growth, yield, quality and propagation traits are Alf-004, S61-019, S54-019, S61-011 and Alf-025. These varieties are expected to contribute towards a sustained quality mulberry leaf production and biodiversity for the silk industry's growth and development.

Keywords - hybridization, genetic, mulberry varieties

INTRODUCTION

Evaluation of any crop is a continuous process to evolve new varieties suitable for specific zones for commercial utilization. The present scenario of sericulture industry demands new varieties suitable for various agronomic conditions. Suitable parent material needs to be identified from the different accessions for the purpose.

Continuous effort has been carried out to develop and select mulberry varieties with desirable traits. In 2001, Almojuela, et al. developed open-pollinated varieties (OPVs) and selected seven promising strains which recorded 30-70% increase in yield per hectare over Batac. The suitability of these OPV's has to be considered from two aspects, agronomic and silkworm rearing. It is essential that mulberry leaves are not only in abundant supply but also of high quality. The quality of mulberry leaves fed to the silkworm is reflected in the quality of silk. Hence, it is vitally important to produce quality leaves to feed silkworms.

Agronomic characters such as good rooting, fast growth, high yield adaptability, pest/disease resistance and drought tolerance are factors in the selection of cultivars. However, the final aim of plant selection is to achieve better yield and a more nutritious product with high moisture content to realize higher cocoon yield and quality. Thus, the present study was conducted to know the performance of the evolved OPV's on growth and yield traits for effective utilization in crop improvement.

OBJECTIVES OF THE STUDY

To evaluate OPVs for sprouting and rooting characters, growth, yield and quality for effective utilization in crop improvement; to identify OPVs with high sprouting and rooting characters; to identify the best OPVs in terms of high growth, yield and quality parameters; to evaluate the seasonal performance of different OPVs in terms growth, yield, and quality parameters; to identify characters associated to high yield of the different OPV's.

MATERIALS AND METHODS

Study 1. Sprouting and Rooting Evaluation of Open-Pollinated Varieties under La Union Condition

Preparation of Nursery Beds and Cuttings

Initially, the planting media was preparedduring summer time, cow dung were gathered, air-dried and pulverized. Sand and soil were hauled and mixed with the pulverized cow dung at a ratio of 1:1:1.

For the sprouting evaluation, 24 nursery beds were prepared measuring 0.5 x 1.0 meters for OPVs. Two hundred cuttings were prepared for each mulberry variety. The cuttings were bundled (50/ bundle), labeled and incubated for five days inside the screen house covered with dried banana leaves.

For the root proliferation study, 24 plastic bags were filled with 1:1:1 mixture of sand soil and humus. Three cuttings were allotted for each bag and replicated thrice.

Disinfection and Planting of Cuttings and Management of the Different Open-Pollinated Mulberry Varieties

Cuttings were disinfected by dipping for one hour in a fungicide solution following the recommended rate. The cuttings were planted in the nursery at a distance of 10 cm x 10 cm and in plastic bag with three cuttings per bag. Varieties were arranged in Randomized Complete Block Design in three replications.

Fertilizer application and other cultural operations for irrigated conditions were followed as per package of practices recommended by the Institute. Watering was done after planting and weekly thereafter. Fertilizer application was done one month after planting. Weeds were removed as required. Saplings were maintained for three months.

Data Gathering

Sprouting and rooting (survival rate) data were gathered 20 and 60 days after planting, respectively. Sprouted cuttings and number of survived saplings were counted.

On root proliferation, data gathering was done after three months of growth. The bags with the grown saplings were submerged in a bucket of water one after the other to loosen the soil. Then saplings were uprooted carefully so as not to damage the root system. Roots were washed in another bucket of water to remove any adhering soil. Saplings were placed for a while on newspaper to absorb water from the roots.

Data were computed as follows:

$$\text{Sprouting percentage} = \frac{\text{Number of sprouted cuttings}}{\text{Total number of planted cuttings}} \times 100$$

$$\text{Rooting percentage} = \frac{\text{Number of survived cuttings 60 days after planting (DAP)}}{\text{Total number of planted cuttings}} \times 100$$

$$\text{Root to shoot Ratio} = \frac{\text{weight of root}}{\text{weight of shoot}} \times 100$$

Data Analysis:

In the sprouting evaluation the eight treatments were replicated three times and laid out in RCBD. Data were subjected to Analysis of Variance across years (2009-2010). Treatment differences were further tested using Duncan Multiple Range Test (DMRT).

Study 2. Growth, Yield and Quality of the Different Open-Pollinated Varieties

Treatments, Field Lay-out and Maintenance of the OPV's

The seven promising OPV's evaluated were Alfonso-004, Alfonso-018, Alfonso-025, Alfonso-028, S_{61} -011, S_{61}-019, S_{54}-019. They were evolved from seedling populations of S54, S61 and Alfonso through open pollination or natural hybridization.

One month before the saplings were ready to be transplanted, the study area was twice plowed, harrowed and leveled. Further, the treatments were laid out into three equal blocks and three furrows were made.

Saplings of all the variety were uprooted with the aid of crowbar. Roots were trimmed to one inch and branches at a length of 0.5 meter. Planting was done last August 2. 2005. The plants were laid out following the Randomized Complete Block Design with three replications. The spacing was 1m between treatments; 0.5 m between hills and 1.75m between blocks.

Recommended cultural management practices were employed uniformly to all treatments. The mulberry plants were pruned at a height of 0.5m. Two weeks after pruning, fertilizer was applied through drill method using mixed urea and complete fertilizer at the rate of 300-120-120 kg per ha/year. Hence a mixture of 10g urea and 32.14 g complete plant^{-1}per application was used. Irrigation followed immediately. Weeding was done twice within 45 days. Sixty days after pruning, data gathering on all the parameters was conducted.

Data Collection

After 60 days of pruning, four plants were randomly sampled from each replication for evaluating the six agronomic traits leaf yield per plant (LY), number of branches per plant (NoB), length of longest shoot (LLS), plant height (PH), moisture content (MC) and moisture retention capacity (MRC). The data on agronomic traits were collected for 4 years and completed 9 harvests from 2007-2010. Procedure for data gathering is as follows:

Leaf Yield Plant^{-1}

All harvestable leaves plant^{-1} were harvested, put in polyethylene plastic bags. Fresh weight was taken immediately using 10 kg capacity weighing scale. Four plants were taken as sample plants. Leaf yield was determined using the equation:

$$\text{Leaf yield (g plant}^{-1}) = \frac{S_1 + S_2 + S3 + S4}{4}$$

Number of Branches

All the branches were counted and recorded.

Length of Longest Shoot (cm)
This was measured from the base of the shoot or branch to the tip of the apical leaf.

Plant height (cm)
The height is the length of the tallest stem. This was measured from the base of the plant to the tip of the largest glossy leaf of the longest branch.

Moisture Content of Leaves (MC)
All harvestable leaves plant^{-1} were harvested, put in polyethylene bags and sealed. Fresh weights of the same were immediately taken using electronic weighing scale. After three days of air drying, the leaves were further oven-dried at 70°C for 48-72 hours till the constant weight was obtained. Moisture content was calculated using the formula:

$$MC\ (\%) = \frac{\text{Fresh weight} - \text{oven dry weight}}{\text{Fresh weight}} \times 100$$

Moisture Retention Capacity (MRC) All harvestable leaves plant^{-1} were harvested, put in polyethylene and sealed. Fresh weight was taken using electronic weighing scale. Then the leaves were kept in open condition at room temperature and then weighed after 6 hours of harvest. Leaves were further dried thoroughly at 70°C for 72 hours in the oven and then weighed. The moisture retention capacity was computed using the formula:

$$MRC = \frac{mg - md}{mg} \times 100$$

Where: MRC – moisture retention capacity
mg – leaf weight after 6 hours
md – oven dry weight of leaves

Other Observations

Recorded data on rainfall, average temperature and relative humidity at the DMMMSU-Agromet Station, NLUC during the research implementation period were taken.

Data Analysis

Data were subjected to Analysis of Variance (ANOVA) across season. Duncan Multiple Range Test (DMRT) was used for further test of significance. In order to measure the degree of association between yield and related characters, the Simple Linear Correlation Analysis was used.

Identification and Selection of Promising OPV's

Promising open pollinated mulberry varieties were identified based on propagation characters, growth, and leaf yield and quality parameters. The criterion for selection was arbitrarily devised by the researcher in which each parameter was given weight expressed in percentage. Leaf yield was given the highest weight of 18%, leaf quality, 15% and propagation traits, 10%. The mulberry varieties were then ranked for all the data gathered with rank 1 with highest value and rank 8 with the lowest value. Then the ranks for all the data of each variety were added. The top five varieties having the lowest ranks were considered promising.

RESULTS AND DISCUSSION

1. Development of Open-pollinated Mulberry Varieties

a. Selection of Parent

The parental materials for the OPVs S54, S61 and Alfonso were selected for higher yield. Alfonso and S54 varieties were the newly registered varieties. Alfonso (NSIC Mb 01) has an entire/lobed leaf, with elliptic leaf, sharp apex, linear base and crenate margin. It is consistently better than the check variety in leaf quality. Its thick leaves, is indicative of high moisture and protein content and relatively high moisture retention capacity that makes it ideal for silkworm feeding. Bioassay of the variety resulted to an increase of 11.56% in the cocoon

yield and longer filament of cocoons. Alfonso found to have high resistance to major diseases of mulberry in La union.

S54 (NSIC Mb 02) differs from Alfonso in its cordate leaf shape, caudate apex, cordate base and crenate margin. S54 is also superior in yield to the widely used variety, Batac, by 23.39% in Ilocos and La Union provinces. It has a short intermodal distance, one of the major contributory characteristics for higher leaf yield, hence considered a good breeding material. It has a high moisture and protein content making it an ideal feed for the production of quality cocoons. Bioassay in silkworm resulted to higher cocoon yield with longer filaments. S54-fed silkworms produced high cocoon shell percentage.

S61 variety is an introduction from India. It possesses also an entire/lobed leaf which is green in color, leaf shape in cordate, caudate apex, cordate base and having crenate margin. S61 is also superior in yield to the widely used variety, Batac by 35.46%. This variety was regarded as ideal for silkworm rearing considering its high moisture content. It was found more suited to the conditions at La Union and Ilocos. Bioassay in silkworm resulted to higher cocoon yield.

b. Progeny Selection of Open-pollinated Mulberry Varieties

Seed extracted from fruits were harvested from open pollinated population of S54, S61 and Alfonso. Seeds collected were sown in earthen pots and maintained for eight months. Preliminary selection or visual observations for desirable characters are made such as height and robustness. Cuttings from such selected strains are prepared and planted in a progeny set-up, grown and maintained for one year with a seedling of 50 (S54), 15 (S61) and 17 (Alfonso). From the Progeny row set up, selection of open-pollinated varieties was done based on leaf yield and leaf texture. Twenty- seven were selected from the lines of S54, 27 from Alfonso and 6 from S61.

c. Production of Saplings

Before cutting preparation nursery beds were prepared by plowing and harrowing once using tractor. Eight seedbeds were prepared with an area of 2m x 1m per bed.

Six to eight months old, pencil sized mulberry branches of Alf-004, Alf-018, Alf-025 Alf-028, S61-019, S61-011, S54-019 and Batac were

pruned. Branches of each of the variety were cut 9-10 cm length with three active buds present in each cutting. One hundred fifty (150) cuttings were prepared and bundled separately in each variety and incubated in rice hay for two days.

Before planting, cuttings were soaked in a Benlate fungicide solution for one hour following the recommended solution. Cuttings of each variety were planted at a distance of 10 cm between cuttings and rows in slanting position. One month after planting twenty (20) g of Urea was broadcasted in each nursery bed and irrigated immediately. Saplings were maintained for eight months prior to transplanting for field evaluation.

Study 1. Sprouting and Rooting Evaluation of Open-Pollinated Varieties under La Union Condition

sPerformance of the Different Open-pollinated Mulberry Varieties on Propagation Characters

Sprouting is the inherent capacity of the strains to unfold the buds and produce new flush of shoots. Capacity and quickness of sprouting determine the subsequent growth and yield in fodder crops and in mulberry is not an exception to this. Sprouting ability determines the success of the establishment of new garden.

Other fundamental considerations in vegetative cultivated crops like mulberry are the rooting ability and root initiation (Hartman and Kester 1976). Mulberry is chiefly propagated through cutting and rooting behavior is an important criterion to be possessed by a variety. Rooting behavior of a variety is purely a genetic character and mulberry is not an exception to this. This method of propagation has been of advantage for easy perpetuations of desirable parental characters without deterioration, producing uniform crop stand and early yield of foliage over a seedling population.

Table 1 presents the result of analysis covering two trials (2009-2010) showing that no significant variation was observed in all the propagation characters of the varieties studied except in fresh weight of shoots. This indicates that almost all traits studied in the different

OPVs and Batac are statistically comparable in spite of the numerically distinct differences noted.

The comparative performance of the different OPV's and Batac on fresh weight of shoots is presented in Fig. 1. Alf-018 showed significantly heavier shoots at 20 g which is 4.28-42.55 % increase over the other varieties. Further, results revealed that five (5) other varieties fared comparably well namely: Alf-025(19.18g), Alf-028(18.97g), S61-011(18.58g), S54-019(17.67g) and S61-019(17.13g). Meanwhile, Alf-004 was found to have significantly lighter shoots at 14.03 g.

Table 1. Mean performance of the different open-pollinated mulberry varieties and Batac on propagation parameters.

Genotype/ Parameters	Sprouting (%)	Rooting (%)	Fresh Weight of Roots (g)	Fresh weight of Shoots (g)	Length of Roots (cm)	Length of Shoot (cm)	Root to Shoot Ratio by weight (%)	Root to Shoot Ratio by Length (%)	Number of Roots
Alf-004	99.33	99.00	4.75	14.03 c	23.38	30.70	40	74	17.26
Alf-018	99.67	77.67	3.08	20.00 a	16.21	26.59	20	51	10.82
Alf-025	100.00	64.33	3.41	19.18 a	16.75	27.17	18	55	11.56
Alf-028	96.00	78.33	3.76	18.97 ab	22.80	30.12	26	64	14.88
S61-011	98.67	89.33	2.84	18.58 ab	22.30	33.27	25	56	10.90
S61-019	99.33	81.33	3.02	17.13 ab	20.15	30.71	24	62	11.68
S54-019	97.00	83.33	3.53	17.67 ab	20.71	29.78	27	57	15.67
Batac	99.67	95.33	3.13	15.92 bc	22.30	31.03	22	60	12.40

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

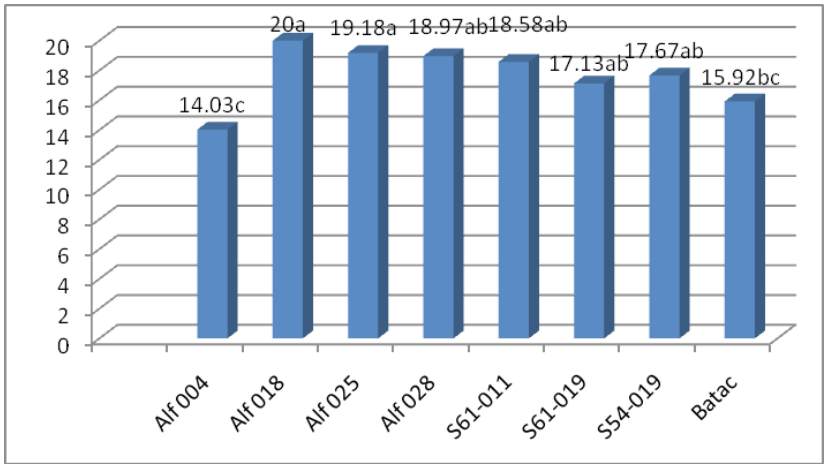

Fig. 1. Comparative performance on fresh weight of shoots of the different open-pollinated varieties and Batac.

Study 2. Growth, Yield and Quality of the Different Open-Pollinated Varieties

A four-year pooled data on mulberry growth, yield and quality parameters covering nine seasons (August 2007, November 2007, March 2008, July 2008, October 2008, March 2009, August 2009, October 2009 and July 2010) are presented.

Climatic Data

Data on rainfall (mm), temperature (°C) and relative humidity (%) during the conduct of the study are presented in Table 2.

Rainfall was heaviest during October 2008 with a total of 1430 mm while only 11 mm of rainfall was recorded in March 2008, the most critical month of irrigating the plants.

During the nine season of evaluations, the minimum temperature ranged from 21.45°C (March 2008) - 24.31° C (July 2010). Likewise, the maximum temperature ranging from 30.77°C- 33.60°C was recorded in the months of March 2008 and July 2010 when faster evaporation of the ground moisture was observed leading to drought condition that was aggravated by low humidity. High volume of water is much needed at this season of evaluation.

The highest relative humidity was recorded during October 2008 (90.30%) while the lowest RH was experienced during July 2008 at 85.09%.

Table 2. Rainfall, temperature (min. and max.) and relative humidity during the growing period of the different OPV's and Batac.

Season	Rainfall (mm)	Temperature(^{0}C) Min.	Max.	Relative Humidity (%)
Aug 2007	1170	23.99	32.53	86.44
Nov 2007	659	22.88	31.36	89.58
Mar 2008	11	21.45	30.77	85.58
July 2008	512	23.41	33.05	85.09
Oct 2008	1430	23.15	31.16	90.30
Mar 2009	26	22.22	31.58	86.06
Aug 2009	1240	23.69	31.87	89.29
Oct 2009	1050	23.49	31.88	89.85
July 2010	586.8	24.31	33.60	85.53

Performance of the Different Open-Pollinated Varieties on Growth, Yield and Quality Parameters (2007-2010)

Table 3 presents the performance of the different open-pollinated varieties and Batac covering nine seasons (2007-2010) showing that there are significant variations among the different OPV's and Batac on the growth, yield and quality parameters.

Leaf Yield (g plant^{-}) Leaf, the major economic unit in sericulture industry, is a direct component of yield. The yield potential of the different varieties is an important factor to be considered in breeding improvement program. The general trend in breeding is to maintain the balance between yield and quality of the leaves.

Table 3. Performance of the different open-pollinated varieties and Batac on growth and yield parameters (2007-2010)

OPV	Leaf Yield (g plant-)	Number of Branches	Length of Longest Shoot(cm)	Plant height(cm)	Moisture content (%)	Moisture Retention Capacity (%)
Alf 004	461.18 a	12.84 a	171.37 a	234.72 a	77.63 ab	w ab
Alf 018	335.03 c	10.53 b	117.73 c	164.66 c	77.55 ab	58.16 bc
Alf 025	336.29 c	8.71 c	119.63 c	163.86 c	78.26 a	60.93 a
Alf 028	258.00 d	10.88 b	101.85 d	143.35 d	76.00 c	56.42 cd
S61-011	339.39 c	13.57 a	119.24 c	176.52 c	76.06 c	57.07 cd
S61-019	397.82 b	11.21 b	144.19 b	207.30 b	77.21 b	56.48 cd
S54-019	392.84 b	13.72 a	128.96 c	198.34 b	76.13 c	55.49 d
Batac	302.03 cd	9.01 c	145.29 b	200.50 b	75.25 d	55.05 d

In a column, means followed by a common letter are not significantly different at 5% level by DMRT

As portrayed in Fig. 2 significant differences were observed among the OPV's in mean leaf yield. Noted with highest yield was Alf-004 (461.18 g plant^{-1}) with 15.93-78.75 % increase over the other OPV's. The lowest yield among the OPVs was produced by Alf-028 at 258g plant^{-1} which is almost similar with that of Batac (302.03 g plant^{-1}), the most commonly used variety by farmers. Second highest in yield but significantly lower than Alf-004 were S61-19 and S54-19 with 397.82 and 392.84 plant^{-1}.

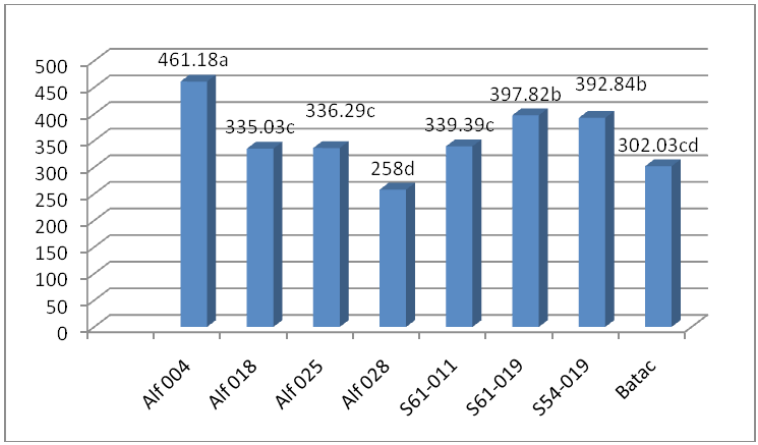

Fig. 2. Comparative leaf yield of the different open-pollinated varieties and Batac

Number of Branches

As presented in Fig. 3, three OPV's, namely, S54-019, S61-011 and Alf-004 have the most number of branches ranging from 12.84-13.72 branches whereas Alf-025 produced the least number of branches (8.71) that differed significantly from the rest of the OPV's. This indicates that S54-019, S61-011 and Alf-004 performed best in terms of number of branches.

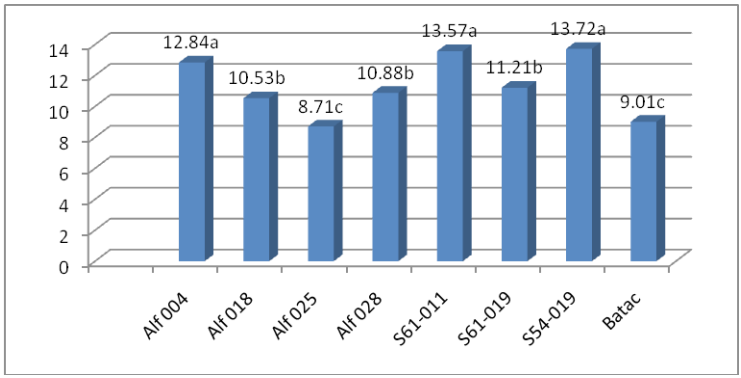

Fig. 3. Comparative number of branches of the different open-pollinated varieties and Batac

Length of Longest Shoot (cm). Result of the analysis showed that significant variations existed among OPV's in terms of longest shoot as shown in Fig. 4. Alf-004 exhibited the longest shoot at 171.37 cm which differed significantly from all other OPV's followed by Batac at 145.29 cm which in turn is comparable with S61-019 at 144.19 cm. On the other hand, Alf-028 was significantly the shortest at 101.85 cm.

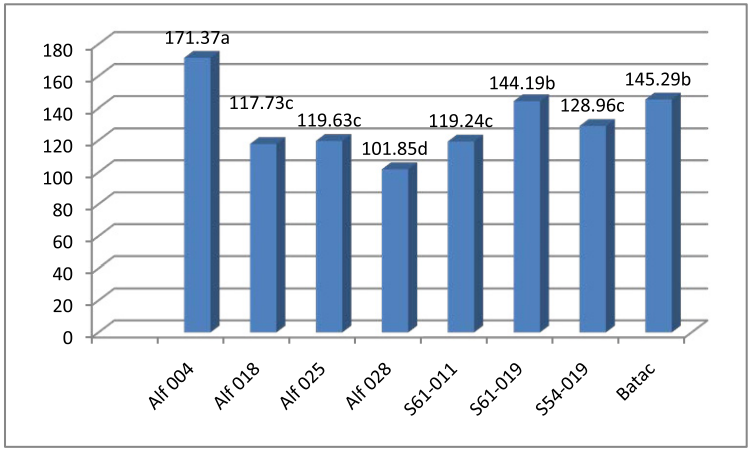

Fig. 4. Length of longest shoot of the different open-pollinated and Batac

Plant Height (cm) Plant height is a characteristic which can be considered an ideotype in the selection of superior plant (Senguptand Dandin 1989). The optimum value for total length of shoot for mulberry is 500 cm and the length of tallest shoot is 150 cm.

The height of the different OPV's is shown in Fig. 5. Alf-004 was markedly tall at 234.72 cm which is the only OPV found promising in terms of plant height. Further, it was significantly higher than all other OPV's with plant height ranging from 143.35 (Alf-028) - 207.30 cm (S61-019).

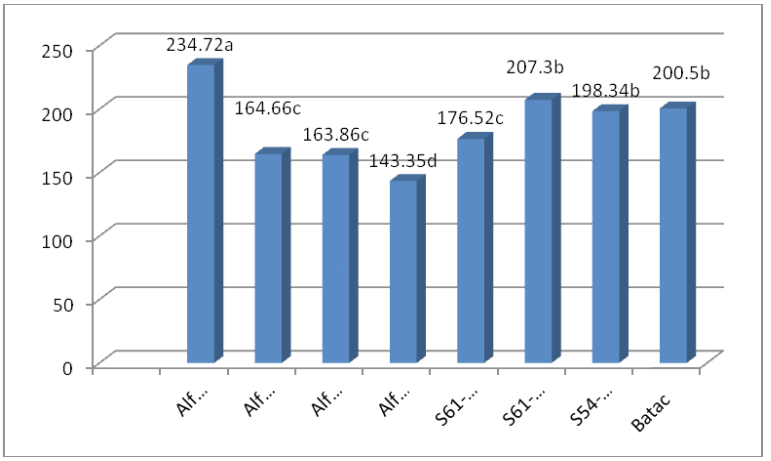

Fig. 5.Comparative plant height of the different open-pollinated varieties and Batac.

Moisture Content (%) A major determinant of nutritive quality of mulberry is the moisture content of the leaves. High moisture and moisture retaining capacity in the leaves have favorable effects on the palatability and assimilability of nutrients for silkworm, thus serves as criteria in estimating the leaf quality (Parpiev 1968). Many scientists reported favorable effect of high moisture content of leaves on their palatability and digestibility of silkworms. Paul et.al (1992) observed in their studies that availability of moisture in the leaves enhances the feeding efficiency of the larvae, thus, increasing the growth rate. Also, silkworm requires higher water content in mulberry leaves to supply the needed increment in their bodies, as stressed by United Nation (1993) and cited by Villamor (2008).

MC of the different OPV's evaluated varied significantly as shown in Fig. 6. Alf-025 recorded the highest MC with a mean of 78.26%. Lower MC of Alf-018 and Alf-004 with a respective mean 77.55-77.63 % did not differ significantly. The results indicate that these varieties have higher palatability and digestibility hence, more suitable than the other varieties. On the other hand, among the OPVs, MC of Alf-028 was lowest at 76.00% which was comparable with S61-011 (76.06%) and S54-019 (76.13%) but among the varieties studied, Batac registered the lowest with 75.25%.

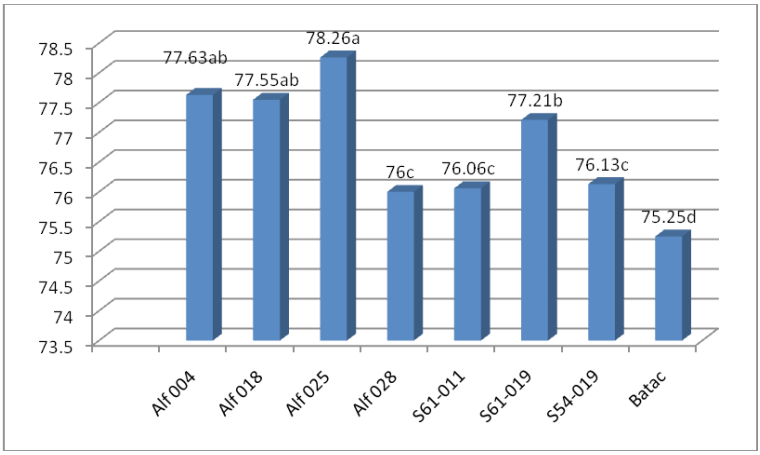

Fig. 6. Comparative moisture content
of the different open-pollinated and Batac

Moisture Retention Capacity (%) The moisture retention capacity has a direct relationship with feeding quality, thus, MRC of leaves is an important consideration in the selection of variety. Moisture retention capacity of quality leaves should be 68% after 6 hours of harvest.

Fig. 7 showed that significant differences were noted in the MRC of the different OPV's. Highest mean MRC was obtained by Alf-025 (60.93%) which performed comparably well with Alf-004 at 59.70 %.Result indicates that Alf-025 and Alf-004 dried up more slowly than the rest of the OPV's. Batac and S54-019 recorded the lowest MRC of leaves of 55.05 and 55.49% but did not differed significantly with the other three OPV's namely Alf-028, S61-019 and S61-011 with their respective mean of 56.42, 56.48 and 57.07 %. However, harvested leaves of OPV's should be provided with effective preservation method to maintain their quality as feed for silkworm.

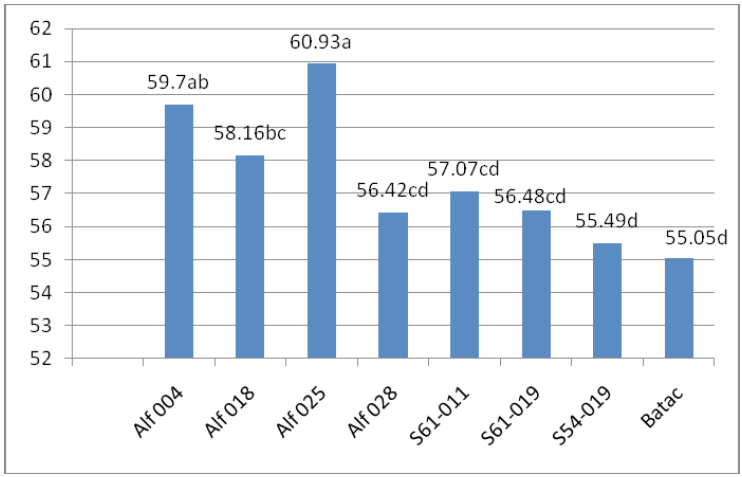

Fig. 7. Moisture retention capacity of the different open-pollinated and Batac

Seasonal Performance of the Different Open-Pollinated Varieties on Growth, Yield and Quality

As presented in Table 4, there are significant seasonal variations on the performance of OPVs in growth, yield and quality.

Highest leaf yield of 652.39 g plant^{-1} was recorded in July 2008 which was significantly higher than the rest of the seasons. Yield was consistently low in March (157.18 and 176.34 g plant) in two years (2008 and 2009, respectively) including yield of July 2010 (262.2 g plant^{-1}).

The most number of branches was produced in March 2008 (18.98). In March, August and Oct 2009, Oct 2008 and July 2010, branches produced markedly dropped to10.54 - 12.33. Number of branches in July 2008 was the least at 7.62.

Mulberries registered significantly the longest shoot at 205.25 cm in August 2007. The shortest was noted in March 2009 at 73.48 cm.

Mean plant height was comparably higher in October 2009 and August 2007 at 227.15 and 209.96 cm respectively. Plant height obtained in March 2009 (136.52 cm) was the shortest.

Leaf quality also varied with season. November 2007 registered the highest MC with a mean of 84.67% which significantly differed from

the rest of the season. In October 2009 exhibited the second highest MC at 78.53% which in turn had a comparable MC in July 2010(76.84%), August 2009 (77.19%), October 2008 (77.34%), and August 2007 (77.27%). The lowest MC was recorded in March 2008 at 72.07%

Leaves harvested in October 2008 recorded the highest MRC at 67.43% which was comparable with leaves harvested during November 2007 (64.86%). MRC dropped to a record low of 57.90% in July 2010 but comparable to MRC in March 2009 (55.71%).

Table 4. Performance of the different open-pollinated varieties and Batacon the growth and yield during the different seasons.

Season	Leaf Yield (g plant-1)	Number of Branches	Length of Longest Shoot (cm)	Plant height (cm)	Moisture content (%)	Moisture Retention Capacity (%)
Aug 2007	548.32 b	9.73 cd	205.25a	209.96 ab	77.27 bc	63.25 b
Nov 2007	424.82 c	7.65 d	149.59 c	206.31 b	84.67 a	64.86 ab
Mar 2008	157.18 e	18.98 a	109.42 d	160.21 c	72.07 d	50.06 d
July 2008	652.39 a	7.62 d	166.22 b	206.73 b	75.28 c	49.66 d
Oct 2008	346.01 cd	10.75 bc	104.33 d	201.85 b	77.34 bc	67.43 a
Mar 2009	176.34 e	11.40 bc	73.48 e	136.52 d	71.68 d	44.59 e
Aug 2009	301.97 d	12.77 b	104.67 d	168.77 c	77.19 bc	57.56 c
Oct 2009	288.13 d	12.33 bc	170.44 b	227.15 a	78.53 b	61.42 b
July 2010	262.24 de	10.54 bc	95.90 d	157.90 c	76.84 bc	57.90 c

In a column, means followed by a common letter are not significantly different at 5% level by DMRT

Correlation Between Growth and Yield Characters
Leaf Yield x Length of Longest Shoot x Plant Height

Leaf yield was significantly correlated with the length of longest shoot and plant height as indicated by the r value of 0.741 and .667 respectively. A variation of 55 and 44% in leaf yield was due to length of longest shoot and plant height. This connotes that an increase in plant height and length of longest shoot significantly increases the leaf yield. This conforms to the findings of Gapuz, C.F. (1998) and Damasco, C.N. (1999). This could be explained by the fact that plant height is the component of the length of longest shoots thus heavier leaf yield per plant is expected.

Leaf yield x Number of Branches

Significant negative association was disclosed between leaf yield and number of branches which connotes that the increase in the number of branches resulted a decrease in leaf yield. Further, It was found that 53.14 % variation in yield per plant is due to the number of branches as indicated by r= -729. This is contrary to the findings of Sarkar et al. (1987) as cited by Datta et.al (2000) who reported positive correlative between branch number with leaf yield hence, suggested to consider this trait for selection of mulberry. Earlier, Das and Krishnaswamy (1969), reported that plant height and branches have positive correlation with leaf yield,

The results also revealed that taller plant and longer shoot significantly contributed to higher leaf yield. These characters are also included in the selection of OPV's for higher leaf yield. Masilamaniet. al (1996) reported that direct selection of plant height trait will be rewarding for mulberry leaf improvement.

Table 5. Correlation matrix of the different growth, yield and quality characters

Parameters	LY	NoB	LLS	PH	MC	MRC
LY Pearson Correlation	1000					
Sig. (2-tailed)	.					
N	9					
NoB Pearson Correlation	-.729*	1000				
Sig. (2-tailed)	.026	.				
N	9	9				
LLS Pearson Correlation	.741*	-.375	1000			
Sig. (2-tailed)	.022	.321	.			
N	9	9	9			
PH Pearson Correlation	.667*	-.432	.837**	1000		
Sig. (2-tailed)	.050	.245	.005	.		
N	9	9	9	9		
MC Pearson Correlation	.378	-.566	.428	.626	1000	
Sig. (2-tailed)	.316	.112	.251	.072	.	
N	9	9	9	9	9	
MRC Pearson Correlation	.278	-.317	.394	.659	.783*	1000
Sig. (2-tailed)	.469	.406	.294	.053	.013	.
N	9	9	9	9	9	9

Legend:

LY- Leaf yield

NoB- Number of branches

LLS- Length of Longest Shoot

PH- Plant Height

MC- Moisture Content

MRC- Moisture Retention Capacity

Identification and Selection of Promising OPVs

In the criteria for selection, the agronomic characters were given a total weight of 55% and the remaining 45% was allotted for the chemical characters and the resulting cocoon yield and quality. Leaf yield and yield related parameters were given a weight of 30%, 15% for leaf quality and 10% for propagation traits. The varieties under study were ranked based on the values of traits computed. The top five varieties were identified as promising.

Table 6 presents the result of evaluation on propagation traits of OPVs for the selection of top performing varieties. Alf-004, Batac, S61-019, S54-019 and Alf-028 were found promising.

As to growth, yield and quality parameters the top five varieties were Alf-004, S61-019, S54-019, S61-011 including Batac (Table7).

Considering the over-all performance on growth, yield, quality and propagation traits, six OPV's were selected and identified as top performing varieties viz; Alf-004, S61-019, S54-019, S61-011and Alf-025.

Table 6. Values and ranks on propagation characters of the different open-pollinated varieties and Batac

OPV	S	Rank	R	Rank	RSR(L)	Rank	NoR	Rank	Total
Alf-004	99.33	**4**	99.00	**1**	74	**1**	17.26	**1**	**7**
Alf-018	99.67	**2**	77.67	**7**	51	**8**	10.82	**7**	**24**
Alf-025	100.00	**1**	64.33	**8**	55	**7**	11.56	**5**	**21**
Alf-028	96.00	**8**	78.33	**6**	64	**2**	14.88	**3**	**19**
S61-011	98.67	**6**	89.33	**3**	56	**6**	10.90	**7**	**22**
S61-019	99.33	**4**	81.33	**5**	62	**3**	11.68	**5**	**17**
S54-019	97.00	**7**	83.33	**4**	57	**5**	15.67	**2**	**18**
Batac	99.67	**2**	95.33	**2**	60	**4**	12.40	**4**	**12**

Legend: S- Sprouting R-Rooting RSR(L)-Root to shoot ratio NoB- Number of roots

Table 7. Values and ranks on growth, yield and quality parameters of the different open-pollinated varieties and Batac.

OPV	LY	Rank	NoB	Rank	LLS	Rank	PH	Rank	MC	Rank	MRC	Rank	Total
Alf-004	461.18	**1**	12.84	**3**	171.37	**1**	234.72	**1**	77.63	**2**	59.70	**1**	**9**
Alf-018	335.03	**6**	10.53	**6**	117.73	**7**	164.66	**6**	77.55	**2**	58.16	**3**	**30**
Alf-025	336.29	**5**	8.71	**8**	119.63	**5**	163.86	**7**	78.26	**1**	60.93	**2**	**28**
Alf-028	258.00	**8**	10.88	**5**	101.85	**8**	143.35	**8**	76.00	**6**	56.42	**6**	**41**
S61-011	339.39	**4**	13.57	**2**	119.24	**6**	176.52	**5**	76.06	**6**	57.07	**4**	**27**
S61-019	397.82	**2**	11.21	**4**	144.19	**3**	207.30	**2**	77.21	**4**	56.48	**5**	**20**
S54-019	392.84	**3**	13.72	**1**	128.96	**4**	198.34	**4**	76.13	**5**	55.49	**7**	**24**
Batac	302.03	**7**	9.01	**7**	145.29	**2**	200.50	**3**	75.25	**8**	55.05	**8**	**35**

Legend:

LY	- Leaf yield	PH	- Plant Height
NoB	- Number of branches	MC	- Moisture Content
LLS	- Length of Longest Shoot	MRC	- Moisture Retention Capacity

CONCLUSIONS AND RECOMMENDATION

Based on the above results, the following conclusions were made:

1. Alf-004, Batac, S61-019, S54-019 and Alf-028 were top five promising in terms of propagation characters evaluated.
2. Alf-004, S61-019, S54-019, S61-011 and Alf-025 were the top five promising in terms of growth, yield and quality.
3. Leaf yield was highest in July 2008. Quality leaves was found best in November 2007 and October 2008.
4. Taller plant and longer shoot significantly contributed to higher leaf yield of the OPV's.

Considering the over-all performance in terms of growth, yield, quality and propagation traits the following OPV's were selected and identified promising viz; Alf-004, S61-019, S54-019, S61-011and Alf-025.

It is recommended that the five selected and identified varieties should be tested for their chemical analysis, pest/diseases resistance and drought resistance.

LITERATURE CITED

Kumar R. and S.B. Dandin
1989 Evaluation of mulberry genotypes for different growth and yield parameters. Genetic Resources of Mulberry and Utilization. P. 146

Sengupta, K and S. B. Dandin
1989 Genetic resources of mulberry and utilization. Central Sericulture Research and Training Institute , Mysore-First edition.

Susheelamma B.N., M.S. Jolly and K. Sengupta
1989 Evaluation of germplasm for stress resistance .Genetic Resources of Mulberry and Utilization. p. 143

INTERNET SOURCES

Singhvi,N.
2000 India Journal of Agricultural Research, 34 (4): 278-280
Retrieved from http://arcjournal.com on June 9,2011

Tikader A. and C. Kamble
2009 African Journal of Plant Science 3(2) 030-036
Retrieved from http://academicjournal.org.on June 14,2011.

Datta.R.K
Mulberry Cultivation and Utilization in India
Retrieved from http://www.fao.org on July 11