MITOTIC CHARACTERS OF *ZEA MAYS* L. cv. SHAN PYAUNG AND LAY TAN PYAUNG IN SHAN STATE

Su May Naung[1] & Thi Thi Htun[2]

Abstract

The two cultivars of *Zea mays* L., Shan pyaung and Lay tan pyaung were observed to determine the karyotype analysis. These samples were supported by Seed Bank; Department of Agricultural Research, Nay Pyi Taw, Yezin. The somatic chromosome number of studied cultivars was 2n=20. The karyotype formulae were varied, 1 ST +1 SM* + 1 SM + 7 M was found in cv. Shan pyaung and 10 M in cv. Lay tan pyaung. A pair with secondary constriction or satellite submedian chromosome was observed in chromosome number 1 (SM1) of cv. Shan pyaung. In cv. Shan pyaung, the longest chromosome with 4.71 µm and the smallest chromosome with 2.18 µm, while the 4.40 µm of longest chromosome and 2.25 µm of smallest chromosome were observed in cv. Lay tan pyaung. The two studied cultivars were significantly different in morphology, karyotypic formula, chromosome group and size. The present study was elucidated to understand the number, morphology of chromosomes, and also beneficial for further research in cytogenetics concern with *Zea mays* L.

Keyword: Karyotype, somatic chromosome, secondary constriction, submedian chromosome

Introduction

Zea mays L., commonly known as maize is annual crop that belongs to the family of grass i.e Poaceae. It is also recognized by different synonyms such as Zea, Corn, silk corn etc. It is native of South America but extensively cultivated in various other countries as well like Myanmar. It is considered as staple article of food in some islands and provinces. It is widely grown in temperate and tropic regions with well drained and fertile soil (Kumar & Jhariya 2013).

Most of the world's food comes from 6 species of grasses: rice, wheat, corn, barley, oats and sorghum. After wheat, corn is the most cultivated cereal in the world because it is a basic component in the diet of the population, as it is a cereal of high nutritional value because it's containing carbohydrates, proteins, oils, vitamins and minerals. This is the reason why large areas are sown on all continents, except in Antarctica (Hipp 2004).

Maize is a tropical grass, well adapted to many climates and hence has wide ranging maturities from 70 days to 210 days (Khan *et al.* 2017). The main corn producing areas in Myanmar are primarily found in the hilly and dry zones of the country with smaller production taking place in the delta and coastal regions. According to government sources, Shan State which is located in the central part of country, accounts for 52 percent of Myanmar's total corn production area while the Ayeyarwady (delta regions), Magwe, and Sagaing regions make up the balance (Anonymous 2016).

Genetically diverse high yielding varieties and hybrids from local and exotic germplasms are used as source materials in the extraction of inbred lines in New Plant Variety Protection Unit Department of Agricultural Research (DAR), Yezin. Hybrid maize research activities are conducted with the primary aim of maize productivity and production in Myanmar to meet and overcome the export demand, and thereby full fill the domestic needs of the country, and to increase productivity and total production of maize in Myanmar. There is a strong need to develop high yielding hybrid maize. A long – term hybrid maize research and development program was

[1] Assistant Lecturer, Department of Biology, Monywa Education Degree College
[2] Dr, Associate Professor, Department of Botany, University of Mandalay

therefore initiated at Department of Agricultural Research (DAR), Yezin in 1974 (Phyu Phwe 2016).

The karyotype, is the typical chromosomal map of a species, which allows us to analyze the chromosome number and the morphology of the chromosomes (shape, size and position of the centromere), information of great value since the chromosomes are guides of phylogenetic affinities and indicators of the systematic classifications (Agreda *et al*. 1991; González *et al*. 2003; Poggio *et al*. 2005).

As well as carrying out studies of populations that are in the process of selection or improvement, with the objective of showing evidence about the frequency changes that occur in maize populations. Similary is important to propose broader karyotypic studies that include a greater number of native races, as well as more exhaustive studies such as fluorescent chromosome bands and genome size estimation (Acosta 2009).

According to Teodoro-Pardo *et al*. (2007), the different karyotypic formula for a species can occur due to genetic variations among the populations, originating from the genome response to the different environments, enlarging the genetic variability for the genus.

In Myanmar, cytogenetic analysis was done by various researchers on many species. More comprehensive studies are needed and in particular a thorough examination of chromosome distribution among some local cultivars of *Zea mays* L. Thus, it is needed to be carried out this research work.

The aim and objectives of this research are to study on karyotype of the two *Zea mays* L. cultivars; to analyze the obtained mitotic chromosome data and to compare their morphological differences of two *Z. mays* L. cultivars.

Materials and Methods

The two cultivars of *Zea mays* L. Shan pyaung (Accession No. 009486) and Lay tan pyaung (Accession No. 011438) were used for this study. The seed samples were obtained from Seed Bank, Department of Agricultural Research, Nay Pyi Taw, Yezin.

The meiotic analysis was done in Department of Biology, Taunggyi Education Degree College. The seeds were germinated on moist filter paper in Petri dishes, kept at room temperature in the dark. After two days, when root lengths were about 1.0 − 1.5 cm the roots were cut and placed in small bottle filled with pre cooled distilled water. Pretreatment was done ice water 0^{o}C to 4^{o}C for 24 hours. The root tips were then transferred into labeled fixation bottles filled with Carnoy's (1889) I solution (1:3 acetic acid and 95% alcohol) for three days.

The root tips were then removed from the fixative and were stained in 2% aceto-carmine for 24 hours at room temperature. The somatic chromosomes were observed using the squash technique (Belling 1921). The two root tips from each seed were used for mitotic analysis. The number of chromosomes was counted from 10 – 15 cells of each root tip. Good plates with well spread chromosomes were photomicrography while measurement of chromosomes was done with an ocular micrometer.

Measurement of (a) length of long arms, short arms and the whole length of chromosome, (b) arm ratio were recorded. Satellites were included in total length to calculate arm ratios. Karyological data were obtained from the ten most definitive cells in each genotype. Arm ratios, centromeric and relative length of each chromosome were calculated according to the following formulae.

(1) Arm ratio = Length of long arm/ Length of short arm

(2) Centromeric index = Length of short arm/ Total length of chromosome

(3) Relative length = Total length of each chromosome /Total complementary length of chromosome × 100

Mean value of short arm length, long arm length and satellite were used to prepare the ideograms. The ideogram was prepared by arranging the chromosomes in such a way that the largest chromosome is placed on the extreme left at number 1 position and the smallest one is placed on the extreme right position in each group of median and submedian (Stebbins 1971).

Results

The morphological characters, diploid somatic chromosome number, karyotype and idiogram of two *Zea mays* L. (maize) cultivars were described in Table 1 to 2 and Figure 1 to 9.

Taxonomic Description

Family	-	Poaceae
Scientific Name	-	*Zea mays* L.
English Name	-	Maize
Myanmar Name	-	Pyaung

Annual erect herbs, monoecious; stems 1.22 – 2.24 m high, solid, well defined nodes and internodes, 10 – 12 jointed swollen nodes; internode 9 – 20 cm in length, the last node end with tassel. Leaves simple, alternate and distichous, exstipulate, sessile; blades linear-lanceolate, 34 – 71 cm long and 4.0 – 9.0 cm wide, the margin entire, hairy, the apex acuminate, scarcely strigose on both surfaces; ligule 0.5 – 1.0 cm long, auriculate. Male inflorescences or tassels terminal paniculate, 27 – 44 cm long, 5 – 16 branched. Female inflorescences or ears axillary, usually 1, sometime 3 – 4, series of paired spikelets in longitudinal rows, the rows usually even number, 4 – 14. Male spikelets paired, one sessile and other pedicellate, with paired glumes; glumes overlapped, bracteate, outer lemma 3-nerved, inner palea 2-nerved, unisexual, zygomorphic; perianth modified into 2 fleshy lodicules, opposite the lemma and alternate the stamens; stamens 3; filaments free, short; anthers versatile, dithecous, dehiscent by longitudinal slit, pale yellow; gynoecium absent. Female spikelets paired, arranged in rows on the central axis or cob, sessile, with paired glumes, thick near the base of ovary, bracteate, represented by lemma and palea, unisexual, zygomorphic; perianth usually absent, sometimes 2, scaly lodicules; androecium absent; gynoecium monocarpellary, unilocular; ovary superior, dome shaped, ovary single ovuled, basal placentation; style long, silky, filiform; stigma long, hairy; fruits or kernels caryopsis, various coloured.

Tasseling Period: Varied according to cultivars.

Outstanding characters of cv. Shan pyaung

Plant height 1.22 – 1.60 m; ear height 0.38 – 0.51 m; jointed swollen nodes 10 – 12 and internodes 9 – 14 cm long. Leaf blades 37 – 69 cm long and 4 – 9 cm wide. Male inflorescences or tassels 35 – 44 cm long with 5 to 7 branches. Female inflorescences or ears only one per plant; silk color pale yellow; ears 21 – 29 cm long and 14 – 15 cm in diameter; female florets arranged in 12 – 14 rows per ear; cobs diameter 11 – 13 cm; kernel rainbow color (mixed with yellow, white, pale purple).

Tasseling Period: 40 – 58 days

Outstanding characters of cv. Lay tan pyaung

Plant height 2.13 – 2.24 m; ear height 0.78 – 0.89 m; jointed swollen 11 – 12 and internodes 9 – 20 cm long. Leaf blades 34 – 71 cm long and 4 – 9 cm wide. Male inflorescences or tassels 27 – 34 cm long with 11 to 16 branches. Female inflorescences or ears 3 - 4 per plant; silk color red; ears 22 – 25 cm long and 8 – 9 cm in diameter; female florets arranged in 4 rows per ear; cobs diameter 6 – 8 cm; kernel white in color.

Tasseling Period: 35 – 50 days

Mitotic characters

The chromosome status of the two *Zea mays* L. cultivars was determined. At the cytological level, both cultivars had 2n = 20 diploid chromosome (Figure 2 and 4). The basic structure of these chromosomes was significantly different. The karyotypic formula of cv. Shan pyaung was 1 ST +1 SM* + 1 SM + 7 M, while in cv. Lay tan pyaung, it was 10M (Table 2).

On observing the size and morphology of somatic chromosomes were classified into three groups in two cultivars, median, submedian and subterminal chromosome. In the cv. Shan pyaung, the median group consisted of 7 chromosome (chromosome number 3 to7, 9 and 10) and regarded as M_1, M_2, M_3, M_4, M_5, M_6 and M_7). The median chromosomes were ranged from mean length of 3.53 ± 0.32 to 2.18 ± 0.09 µm. The centromeric index ranged from 0.49 ± 0.01 to 0.47 ±0.01 and the relative length ranged from 11.26 ± 0.63 to 6.99 ± 0.39. The chromosome no. 1 and 2 were submedian and recorded as SM_1* and SM_2. The submedain chromosomes were ranged from mean length of 4.71 ± 0.41 to 3.84 ± 0.11µm. The centromeric index ranged from 0.34 ± 0.05 to 0.41 ± 0.01 and the relative length ranged from 15.07 ± 1.88 to 12.27 ± 0.32. Chromosome number 8 belonged to subterminal (ST_1) (Table 2).

In cv. Lay tan pyaung, chromosome number 1to 10 were median, regarded as M_1, M_2, M_3, M_4, M_5, M_6, M_7, M_8, M_9 and M_{10} respectively. All members were ranged from 4.40 ± 0.67 to 2.25 ± 0.20 µm. The centromeric index ranged from 0.49 ± 0.01 to 0.47 ± 0.01. The relative length ranged from 15.10 ± 2.25 to 7.74 ± 1.09 µm (Table 1).

Comparison on Chromosome Group

Median Group

The cultivars Shan pyaung had seven median chromosomes, while the cv. Lay tan pyaung possessed ten median chromosomes. The total length of median group of cultivars Lay tan pyaung was found the longest being (4.40 ± 0.67) while that of cultivar Shan pyuang was considered the shortest with (2.18 ± 0.09) in length. The arm ratios were ranged from 1.15 to 1.06. All the median chromosomes of the two maize cultivars studied ranged from 15.10 to 6.99 in relative lengths (Table 1 and Figure 2 to 9).

Submedian Group

The satellite was attached to the chromosomes number one of cv. Shan pyaung, which was submedian type and the longest chromosome. The cv. Shan pyaung was possessed two submedian chromosome. The total length of two submedian chromosomes were observed (4.71 ± 0.41) and (3.84 ± 0.11). The arm ratios were ranged from 1.44 to 1.42. The two submedian chromosomes of the cv. Shan pyaung ranged from 15.07 to 12.27 in relative lengths (Table 1 and Figure 2 and 9)

Subterminal Group

The cultivar Shan pyaung had only one subterminal chromosome. The total length, arm ratio and relative length of the subterminal chromosome were 2.54 ± 0.23, 1.51 and 8.10 (Table 1 and Figure 2 and 9).

Table 1 Somatic chromosome characters (total, ratio and designation) of *Zea mays* L. cultivars

	Characters	Chr. No. 1	Chr. No. 2	Chr. No. 3	Chr. No. 4	Chr. No. 5	Chr. No. 6	Chr. No. 7	Chr. No. 8	Chr. No. 9	Chr. No. 10
Shan pyaung	Total length	4.71 ± 0.41	3.84 ± 0.11	3.53 ± 0.32	3.26 ± 0.27	3.10 ± 0.26	2.91 ± 0.17	2.76 ± 0.06	2.54 ± 0.23	2.45 ± 0.19	2.18 ± 0.09
	L	2.24 ± 0.16	2.26 ± 0.10	1.83 ± 0.14	1.70 ± 0.13	1.60 ± 0.13	1.54 ± 0.09	1.45 ± 0.05	1.53 ± 0.18	1.28 ± 0.09	1.16 ± 0.06
	S	1.58 ± 0.11	1.58 ± 0.06	1.70 ± 0.18	1.56 ± 0.17	1.50 ± 0.14	1.40 ± 0.09	1.31 ± 0.03	1.01 ± 0.05	1.18 ± 0.11	1.02 ± 0.03
	Satellite	1.09 ± 0.12	-	-	-	-	-	-	-	-	-
	Arm ratio	1.42 ± 0.02	1.44 ± 0.09	1.09 ± 0.03	1.10 ± 0.05	1.07 ± 0.03	1.10 ± 0.05	1.11 ± 0.04	1.51 ± 0.10	1.09 ± 0.03	1.15 ± 0.02
	Designation	SM1*	SM2	M1	M2	M3	M4	M5	ST1	M6	M7
	C.I	0.34 ± 0.05	0.41 ± 0.01	0.48 ± 0.01	0.48 ± 0.01	0.49 ± 0.01	0.48 ± 0.01	0.48 ± 0.01	0.40 ± 0.02	0.48 ± 0.01	0.47 ± 0.01
	R. L	15.07±1.55	12.27±0.32	11.26±0.63	10.40±0.58	9.91 ± 0.54	9.37 ± 0.25	8.82 ± 0.29	8.10 ± 0.44	7.83 ± 0.51	6.99 ± 0.39
Lay tan pyaung	Total length	4.40 ± 0.67	3.96 ± 0.45	3.62 ± 0.36	3.31 ± 0.21	3.25 ± 0.20	3.17 ± 0.25	2.93 ± 0.28	2.75 ± 0.25	2.54 ± 0.18	2.25 ± 0.20
	L	2.26 ± 0.34	2.07 ± 0.25	1.91 ± 0.17	1.74 ± 0.14	1.71 ± 0.12	1.66 ± 0.13	1.54 ± 0.18	1.42 ± 0.13	1.33 ± 0.11	1.19 ± 0.10
	S	2.14 ± 0.32	1.89 ± 0.21	1.71 ± 0.20	1.57 ± 0.08	1.55 ± 0.09	1.51 ± 1.13	1.39 ± 0.11	1.33 ± 0.12	1.23 ± 0.09	1.07 ± 0.11
	Satellite	-	-	-	-	-	-	-	-	-	-
	Arm ratio	1.06± 0.03	1.10 ± 0.04	1.13 ± 0.05	1.11 ± 0.05	1.11 ± 0.05	1.11 ± 0.07	1.12 ± 0.07	1.07 ± 0.03	1.08 ± 0.05	1.12 ± 0.06
	Designation	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
	C.I	0.48 ± 0.02	0.48 ± 0.01	0.47 ± 0.01	0.48 ± 0.01	0.48 ± 0.01	0.48±0.001	0.48 ± 0.02	0.49±0.004	0.49 ± 0.01	0.48 ± 0.01
	R. L	15.10±2.25	13.70±2.78	12.49±2.16	11.48±2.31	11.21±1.86	10.94±1.93	10.24±1.94	9.48 ± 1.67	8.77 ± 1.46	7.74 ± 1.09

L=Long arm, S = Short arm, ST = Subterminal, SM= Submedian, M = Median, C.I = Centromeric index, R. L = Relative Length, Chr. = Chromosome

Table 2 Comparison of karyotypic formula of *Zea mays* L. cultivars

No.	Cultivars	Karyotypic formula
1	Shan pyaung	1 ST + 1 SM*+ 1 SM + 7 M
2	Lay tan pyaung	10 M

ST = Subterminal chromosome, SM = Submedian chromosome, M = Median chromosome, * = Satellite

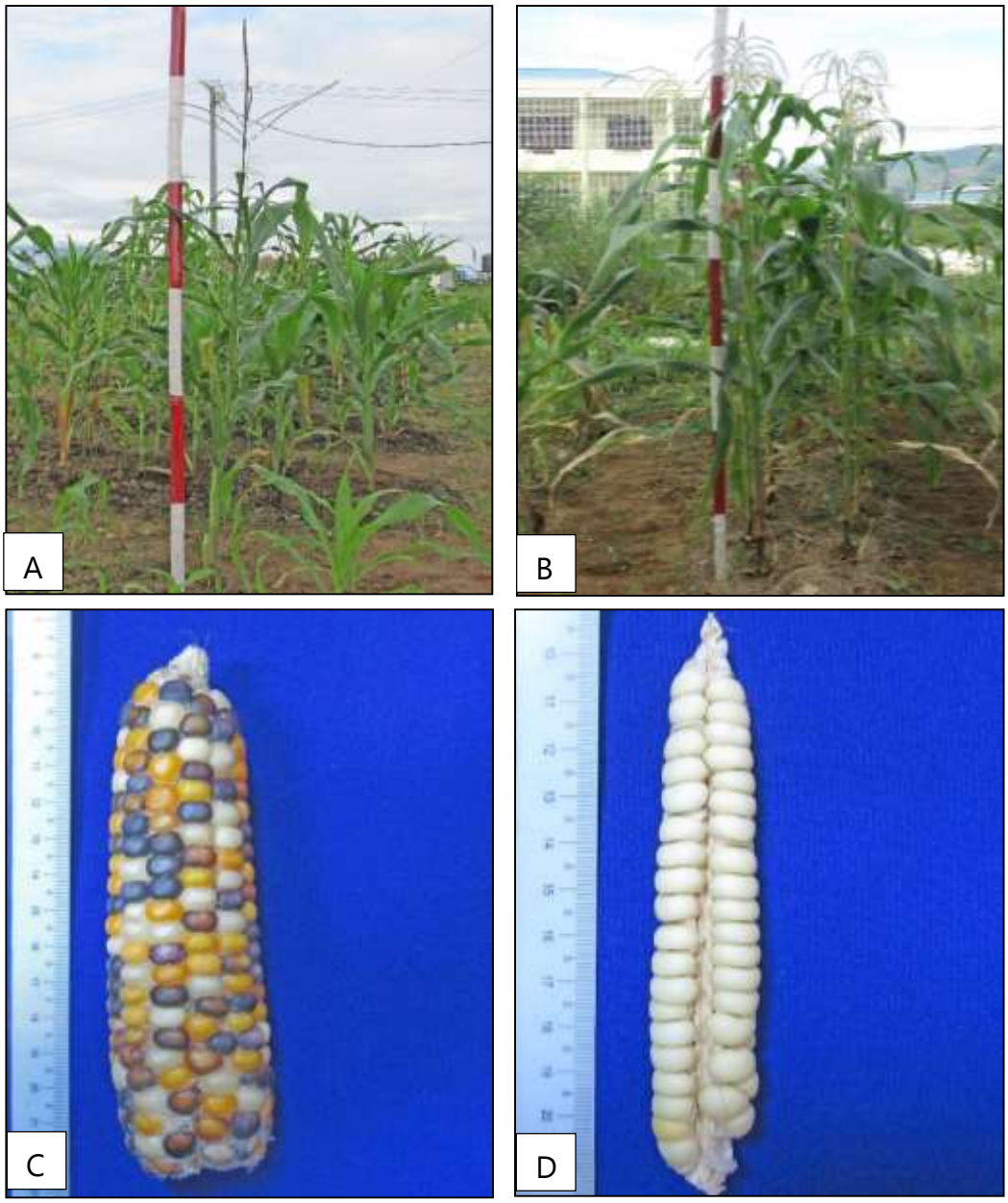


Figure 1 Morphological characters of *Zea mays* L. cv. Shan pyaung and Lay tan pyaung
A. Habit of cv. Shan pyaung B. Habit of cv. Lay tan pyaung
C. Cob of cv. Shan pyaung D. Cob of cv. Lay tan pyaung

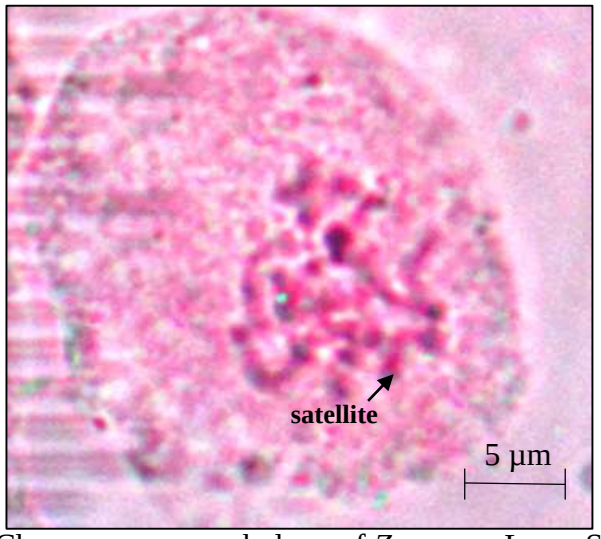


Figure 2 Chromosome morphology of *Zea mays* L. cv. Shan pyaung

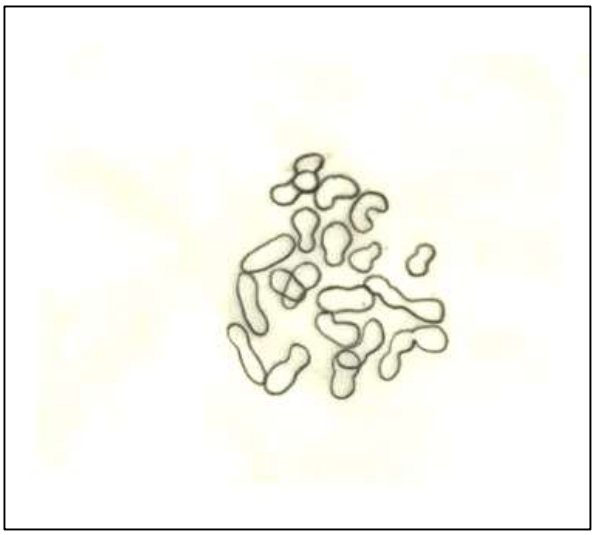


Figure 3 Chromosome outline of *Zea mays* L. cv. Shan Pyaung

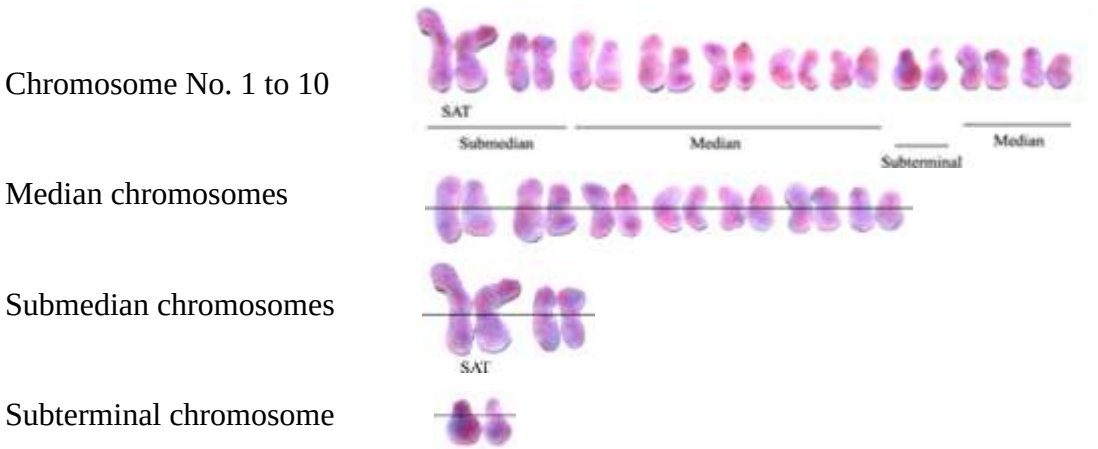


Figure 4 Karyotype of *Zea mays* L. cv. Shan pyaung

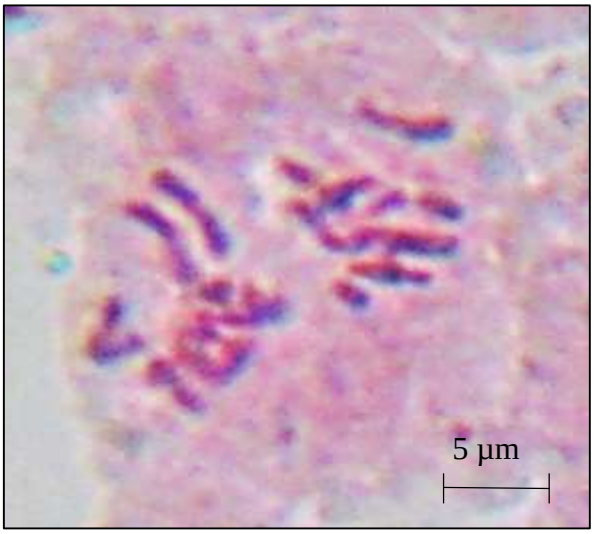


Figure 5 Chromosome morphology of *Zea mays* L. cv. Lay tan pyaung

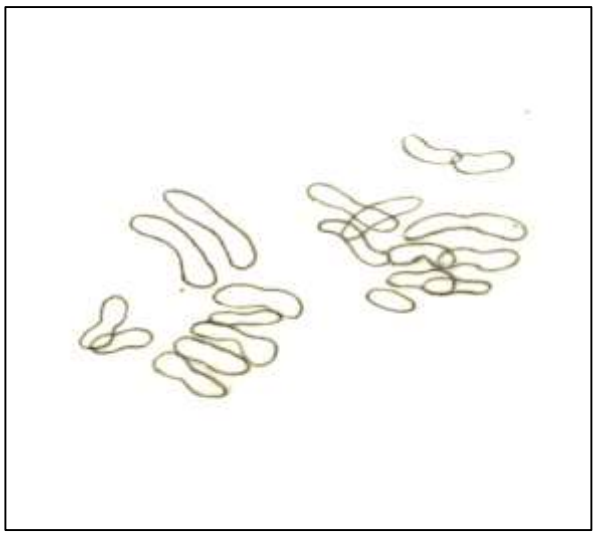
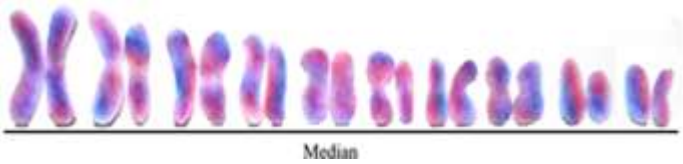


Figure 6 Chromosome outline of *Zea mays* L. cv. Lay Tan Pyaung

Chromosome No. 1 to 10



Median chromosomes

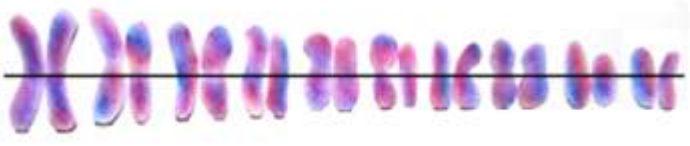


Figure 7 Karyotype of *Zea mays* L. cv. Lay tan pyaung

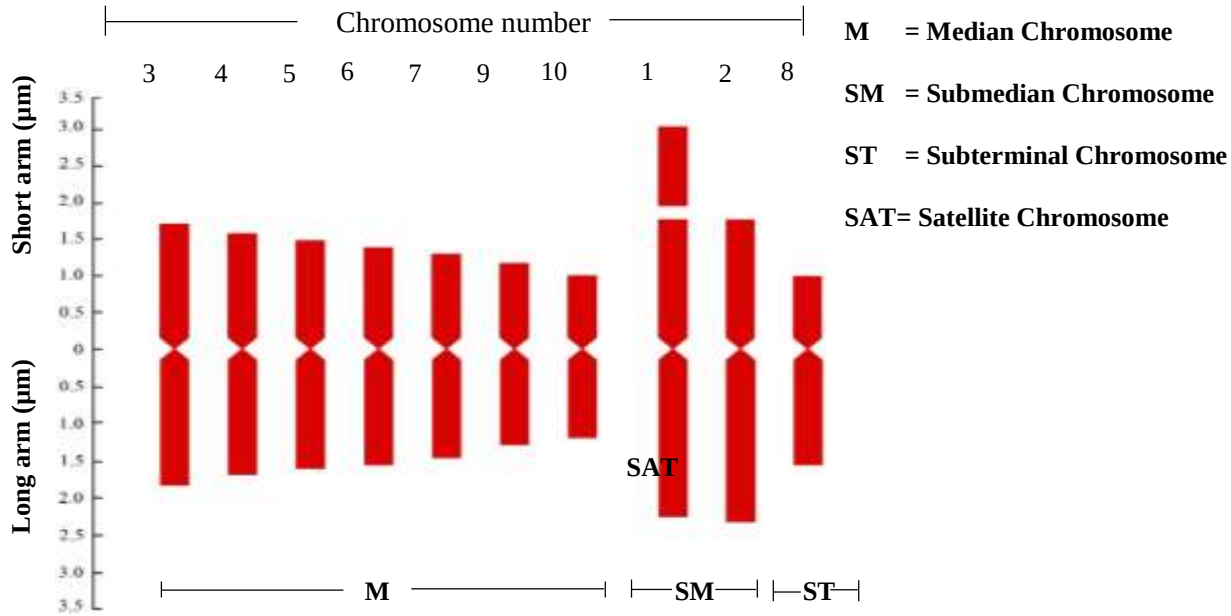


Figure 8 Idiogram of *Zea mays* L. cv. Shan pyaung

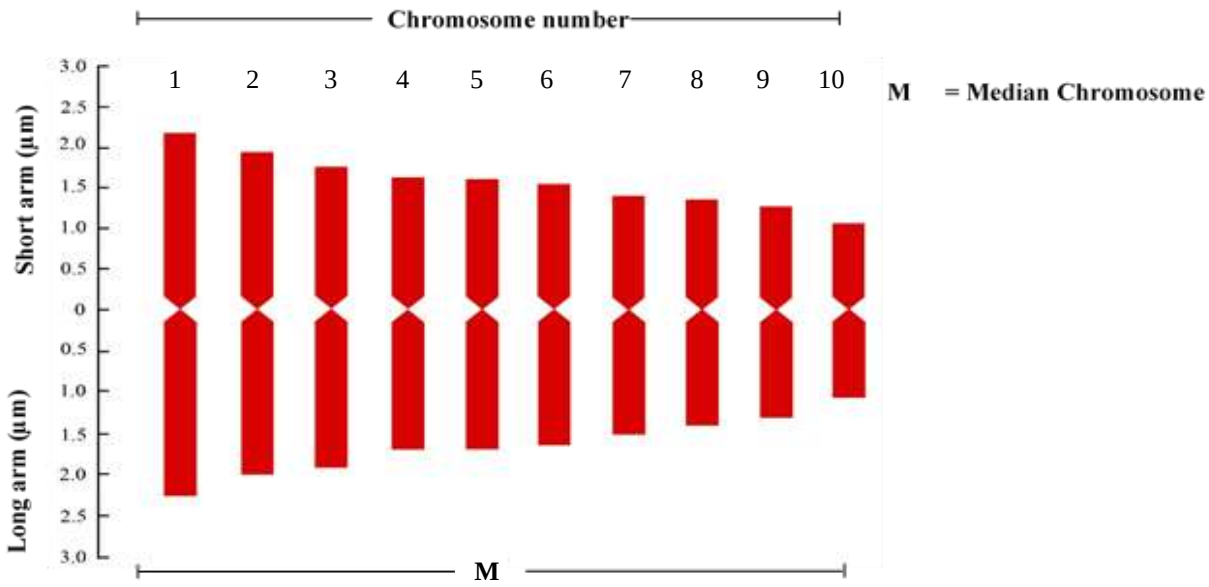


Figure 9 Idiogram of *Zea mays* L. cv. Lay tan pyaung

Discussion and Conclusion

Maize is an annual grass growing up to 4 m tall and monoecious. The female inflorescences, the ears, develop in leaf axils on the stalk; which terminates in the male inflorescence, the tassel. The broad leaf sheaths are overlapping around the stalk and the leaves are arranged in two opposing rows along the stalk, Maize has a multitude of uses and is used in the preparation of food or drinks, as animal feed or for industrial purposes.

The morphology and mitotic chromosome behavior of the two cultivars were studied in this study. The varied morphological characters were observed in this research. The cultivar Lay tan pyaung had significant mean number of plant height, ear height, node per plant, internode length and ear per plant among the two cultivars. The range of tassel length in cv. Shan pyaung was longer

(35 – 44 cm) than the cv. Lay tan pyaung (27 – 34 cm), while the cv. Shan pyaung was possessed low branch per tassel (5-7) than cv. Lay tan pyaung (11-16). The kernel color of the two studied cultivars were also significantly different. These finding were agreement with Goodman & Brown 1988, many varieties or "races" of maize differ in physical properties.

The shortest tasseling period was observed in cv. Lay tan pyaung (35 – 50 days) and the longest period was in cv. Shan pyaung (40 – 58 days). This result was agreed with the finding of Kuleshov & Am (1993), who stated that the flowering time reflects the adaptation of a plant to its environment to local climatic effects. Maize landraces vary widely, from 2 to 11 months, for the time required to mature.

Mitotic chromosome counts for the two cultivars showed 2n = 20. The chromosomes were generally different in their size and centromeric position. This result was agreed with McClintock *et al.* 1981, who reported that the maize has 10 chromosomes (n =10) with relatively large differences in size. The ten chromosomes are all morphologically distinguishable by their structural characteristics, such as relative length, centromere position, satellite, numbers and positions of chromosomal knobs.

In cv. Shan pyaung, one pair of subterminal chromosomes, two pairs of submedian chromosomes and seven pairs of median chromosomes. The SM1 possessed the satellite chromosomes and 1.09 ± 0.12 µm in length. The karyomorphological formula of cv. Shan pyaung was 1 ST+ 1 SM* + 1 SM + 7 M. This is an agreement with the previous mitotic study Silva *et al.* (2018), who studied that the satellite chromosome in submedian chromosome while 0.053 ± 0.009 µm in length was observed. Ten pairs of median chromosomes and 10 M of karyomorphological formula were found in cv. Lay tan pyaung. This result was agreed with Gonzales and Poggio (2011), there was not found satellite chromosomes in their studied maize cultivars.

The median chromosomes (M) were found in chromosome no. 3 to 7 and 9 to 10 in cv. Shan pyaung, while no.1 to 10 in cv. Lay tan pyaung. The mean of total length for median chromosomes were ranged from 4.40 ± 0.67 (cv. Lay tan pyaung) to 2.18 ± 0.09 µm (cv. Shan pyaung). Medina *et al.* (2018) proposed the mean total length of median chromosomes were 4.16 ± 2.04 µm to 2.04 ± 0.09 µm.

The submedian chromosomes (SM) were observed in chromosome no. 1 and 2 of cv. Shan Pyaung, while there was not found submedian chromosome in cv. Lay tan pyaung. The mean total length of SM chromosomes was ranged between 4.71 ± 0.41 µm to 3.84 ± 0.11µm. Medina *et al.* (2018) observed the mean total length of submedian chromosomes were 3.23 ± 0.14 µm to 1.88 ± 0.04 µm. The subterminal chromosomes (ST) were only occurred in chromosome no. 8 of cv. Shan pyaung and the mean total length 2.54 ± 0.23 µm. Ehbucha *et al.* (2016), they reported the mean total length of subterminal chromosome was 2.28 µm.

The total length of the chromosomes was different among the two maize cultivars, as observed in some other studies (Egbucha *et al.* 2016; Medina *et al.* 2018). The present study showed that total length of chromosomes of maize cultivars were ranged between 4.71 to 2.18 µm in cv. Shan pyaung and 4.40 to 2.25 µm in cv. Lay tan pyaung. Therefore, total length of chromosomes found in this study were longer than those reported earlier. Variation in the degree of chromosome condensation may be well due to the use of different root tip pretreatment methods (Tayyar *et al.* 1994). The significant differences of chromosome sizes between two maize cultivars were seen in chromosome no. 1 and 6. A few differences of chromosome sizes were found in chromosome no. 2, 3, 4, 5, 7, 8, 9 and 10.

In the present study, cv. Shan pyaung possessed nucleolus organizer (satellite chromosomes) body. Sears and Sears (1979) stated from five years studied on wheat cytogenetics chromosomes (i.e. having nucleolus organizers) are stable in chromosome segregation as well as adapted to their growing conditions. Therefore, it seems that the cv. Shan pyaung well adapted to their growing conditions.

Karyomorphology and chromosome number of a variety or species are useful in its identification and also in establishing the relationships among related species (Lavania & Srivastava 1999; Liu *et al.* 2000). The importance of cytological information to crop improvement cannot be over emphasized. Cytological studies have helped a lot in resolving the origin and evolution of plant species (Aliyu & Awopetu 2007).

In conclusion mitosis chromosome number of the studied cultivars 2n = 20 were observed, while they were different in morphological characters, karyomorphological formulae, chromosome group and size. The present data of karyology of the two maize cultivars will be assisted to classify the maize cultivars grown in Shan State and more helpful to identify the cytogenetic and cytotaxonomic characters.

Acknowledgements

I would like to mention my appreciation to Dr Nu Nu Yee, Professor and Head, Department of Botany, University of Mandalay for her kind permission to carry out this research. My special thanks to my supervisor, Dr Thi Thi Htun, Associate Professor, Department of Botany, University of Mandalay for her invaluable guidance and advice in this research.

References

Acosta, R. (2009). El cultivo del maiz, su origen y clasificación. El maiz en Cuba. Cultivos Tropicales. 30(2):113-120.

Agreda, S., E. Ferres and M. Montesinos. 1991. Manual de embryologia Y anatomia general. Valencia, Espana: Editorial Universitat de Valencia.

Albert, P.S., Z. Gao, T.V. Danilova and J.A. Birchler. (2010). Birchler. Diversity of chromosomal karyotypes in maize and its relatives. Cytogenet. Genome Res. 2010; 129 (1–3):6–16.

Aliyu, O. M. and J. A. Awopetu. (2007). Chromosome studies in Cashew (*Anacardium occidentale* L.) African Journal of Biotechnology. Vol. 6 (2): pp.131 – 136.

Anonymous. (2016). Corn Production, Supply and Demand Update 2016, USDA Foreign Agricultural Service, Global Agricultural Information Network, GAIN Report Number: BM 6014, Approved by: Rey Santella, Agricultural Attaché.

Belling, J. (1921). On counting chromosomes in pollen mother cells. Am Nat 55: 573- 574.

Bonamico, N., J. Aiassa, M. Ibáñez, M. Di Renzo, D. Díaz and J. Salerno. (2004). Characterization and classification of single cross hybrids of maize with SSR markers. Revista de Investigaciones Agropecuarias. 33(2), 129-144.

Bonamico, N., J. Aiassa, M. Ibáñez, M. Di Renzo, D. Díaz and J. Salerno. (2004). Characterization and classification of single cross hybrids of maize with SSR markers. Revista de Investigaciones Agropecuarias. 33(2), 129-144.

Carnoy's, J. B., (1886). "La cytodierese I" ocuf. Cellule, 3, I.

Egbucha, K., C. A. Duke and I. Hawau. (2016). Karyotype Analysis in *Zea mays* L. Var. Everta (Popcorn) Cultivated Within Owerri, Southeast Nigeria. International Journal of Research in Applied, Natural and Social Sciences (IMPACT: IJRANSS) ISSN (P): 2347-4580; ISSN (E): 2321-8851 Vol. 4, Issue 7, Jul 2016, 127-132 © Impact Journl patterns in the annual species of Cicer. Genome, 37: 656-663.

Gonzales, G.E. and L. Poggio. (2011). Karyotype of *Zea luxurians* and *Z. mays* ssp. *mays* using FISH/DAPI, and analysis of meiotic behavior of hybrids. Genome. 2011; 54(1):26–32

Gonzales, P., M. Caballero, A. Santisteban and P. Serrano. (2003). Prácticas de laboratorio y de aula. Madrid, España: Editorial Narcea S.A.

Goodman, M. M. and W. L. Brown. (1988). Corn and Corn Improvement, edited by Sprague, G. F. & J. W. Dudley. American Society of Agronomy, Madison, WI. Races of corn, pp. 39– 74.

Hipp, A. (2004). El maíz, por dentro y por fuera. New York, United States of America: Editorial the Rosen Publishing Group.

Khan, M., K. Khan, S. U. Afzal, N. Ali, M. M. Anjum, H. Usman and M. O. Iqbal. (2017). Seed Yield Performance of Different Maize (*Zea mays* L.) Genotypes under Agro Climatic Conditions of Haripur. International Journal of Environmental Sciences & Natural Resources.

Kuleshov, N. N. and J. Am. Soc. Agron. 25, 688 (1993).

Kumar, D. and N.A. Jhariya. (2013). Nutritional, medicinal and economical importance of corn. Research journal of Pharmaceutical Sciences,2,7-8.

Lavania, U.C. and S. Srivastava. (1999). Quantitative declination of karyotype variation in Papaver as a measure of phylogenetic differentiation and origin. Curr. Sci. 1999; pp: 429- 435.

Liu, J.H.T., S. Chen and A. Lu. (2000). Karyomorphology of *Biebersteinia Stephan* (Geraniaceae) and its systematic and taxonomic significance, Bot. Bull. Acad. Sin., 425: 61- 66.

McClintock, B., T.A. Kato-Y and A. Blumenschein. (1981). Chromosome constitution of races of maize. Colegio de postgraduados, Chapingo, Mexico.

Medina, S. E. L., J. M. Léon, C. H. Q. Jara, A. E. G. Rivero and M. F. R. C. Leon. (2018). Karyotype of native *Zea mays* ssp. *mays* Proto-Confite morocho. Biological Sciences Faculty, National University of Trujillo, Peru.

Phyu Phwe. (2016). Situation of corn in Myanmar, New Plant Variety Protection Unit. Department of Agricultural Research (DAR).

Poggio, L., G. Gonzalez, V. G. Confalonieri, C. Comas and C. Naranjo. (2005). The genome organization and diversification of maize and its allied species revisited: evidences from classical and FISH-GISH cytogenetic analysis. Cytog. Gen. Res. 109(13):259–267.

Sears, E.R. and M. S. Sears. (1979). The telocentric chromosome of common wheat. In Ramamujan ed. Proc. Fifth Intl. Wheat Gent Symp. New Delhi. India. Pp. 389- 407.

Stebbins, G.L. (1971). Chromosomal evolution in higher plants. London: Edward Arnold `Puplishers.

Tayyar, R. I., A. J. Lukaszewski and J. G. Waines. (1994). Chromosome banding patterns in the annual species of *Cicer*. Genome, 37: 656 – 663.

Teodoro-Pardo, C. V., A. Garcia-Velazqez, and T. Corona-Torres. (2007). Polimorfismo cromossômico en *Capsicum annuum* L. (Solanaceae) em recolectas de Puebla, Morelosy Quartenário, México. Agrociencia, v.41, p.873-881, 2007.