MEIOTIC CHARACTERS OF *ZEA MAYS* L. CV. PAUK PAUK PYAUNG NI AND PHU SAR PYAUNG IN SHAN STATE

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Abstract

The two cultivars of *Zea mays* L., Pauk pauk pyaung ni and Phu sar pyaung were studied to determine the morphology and meiotic characters. This research was done in Department of Biology, Kyaing Tong Education Degree College, Shan State during June to December 2020. In morphology, the silk and kernel color of the two *Z. mays* L. cultivars were significantly different. The meiotic chromosomes behavior of all studied *Z. mays* L. cultivars were observed 2n = 20, in the diakinesis stage. The lowest univalent, trivalent and quadrivalent (ring, chain and total) chromosomes were observed in *Z. mays* L. cv. Pauk pauk pyaung ni. The maximum mean value of ring and total bivalent chromosomes were also found in *Z. mays* L. cv. Pauk pauk pyaung ni. The chiasmata frequency and normal pollens of cv. Pauk pauk pyaung ni was also significantly superior than the *Z. mays* L. cv. Phu sar pyaung. The chromosome configuration of the *Z. mays* L. cv. Pauk pauk pyaung ni was 0.05 I + 1.35 oII + 8.38 cII + 0.15 III + 0.03 oIV + 0.03 cIV and 0.38 I + 2.15 oII + 7.18 cII + 0.23 III + 0.03 oIV + 0.03 cIV in cv. Phu sar pyaung. In *Z. mays* L. cv. Pauk pauk pyaung ni was found the low laggard and bridge chromosomes in anaphase I and telophase I. Therefore, the *Z. mays* L. cultivar Pauk pauk pyaung ni should be selected for inbreed experiment for future researches.

Keywords meiotic characters, chiasmata frequency, chromosome configuration

Introduction

Zea mays L. is a grain crop belonging to the grass family Poaceae (Paliwal, 2000) and is the only cultivated species of importance in the tribe Mydeae (Salian, 2007). The center of origin for *Z. mays* L. has been established as the Mesoamerican region, now Mexico and Central America (Watson & Dallwitz, 1992). According to Harris *et. al*. (2007), maize is the third most important crop in the world, after rice and wheat. The crop is of significant economic importance worldwide as human food, animal feed and as a source for a large number of industrial products (Paliwal, 2000). In developing countries maize forms part of the staple diet (Du-Plessis, 2003). Rouanet (1992) stated that maize is an industrial raw material for a growing range and variety of food and non-food products as it is used for human consumption, animal feed and for industrial purposes.

In Myanmar, Khaing Khaing Htwe (2020) stated that, maize is the second most important cereal after rice, and is grown in the whole country except in Mon State. It is important for animal feed for domestic livestock farms, and for export. In 2017-2018, about 1,437 thousand metric tons of maize was exported to China and the Philippines. As demand for maize has increased annually since 2009, the maize growing area has expanded (Anonymous, 2018). About 50 % of Myanmar maize production is exported.

Maize is a naturally outcrossing species, which makes its genetic architecture (diversity, linkage, recombination, etc.) more similar to other outcrossing organisms such as humans rather than self-pollinating plants (Wallace *et. al*., 2013). While its genetics are similar to humans, maize retains the major strength of plant genetics: the ability to self-cross and quickly produce homozygotes or F_2 populations.

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Meiosis is a specialized mechanism by which sexually reproducing species reduce their genomes from diploid to haploid, and the underlying mechanisms are highly conserved among eukaryotes (John, 1990). In general, the process of meiosis is under genetic control and consists of commitment and initiation, homologous chromosome pairing and synapsis, interhomolog reciprocal recombination, disjunctive segregation, and haploid gamete or gametophyte formation. Interhomolog chromosome recombination between parental chromosomes during meiotic prophase I establishes physical connections for bipolar spindle attachment between the homologs, and it generates novel allelic combinations (Murphy & Bass, 2012).

Meiosis is an event of high evolutionary stability that culminates in the reduction of chromosome number in gametes. Cytological events of meiosis are controlled by a large number of genes acting from pre-meiosis to the post-meiotic mitoses (Golubovskaya, 1989). Mutations of these genes may cause anomalies that impair plant fertility (Curtis & Doyle, 1991).

In Myanmar, cytogenetic analysis was done by various researchers on many species. More comprehensive studies are needed and in particular a thorough examination of meiosis and post meiotic characters among some local cultivars. Thus, the meiotic chromosome behaviors on two local cultivars of *Zea mays* L. was carried out in this research work. The aim and objectives of this research are to study the meiosis characters of two *Z. mays* L. cultivars, to compare their morphological differences and genetic stability.

Materials and Methods

The seeds of *Zea mays* L. cultivars, Pauk pauk pyaung ni (Accession No. 011446) and Phu sar pyaung (Accession No. 011793) were used for this study. The seed samples were obtained from Seed Bank, Department of Agricultural Research, Nay Pyi Taw, Yezin, Mandalay Region. The PMC (Pollen Mother Cells) of these cultivars were used in meiosis analysis.

The two cultivars of *Zea mays* L. were sown in the Kyaing Tong Education Degree College, Kyaing Tong Township, Shan State in June - December 2020 for morphological characters and meiotic analysis. Each plot size was 3.05 meter in length and 0.91 meter in width with twenty plants per plot. Each cultivar was sown in two rows, 0.46 meter between rows and 0.31 meter between plants.

For meiotic analysis, the young floral buds were collected between 6 a.m. to 10 a.m. about nine weeks after sowing, which were fixed in Carnoy's I (1886) solution. The sixty cells for each cultivar were studied. The Pollen Mother Cell (PMC's) was studied by squash technique (Belling, 1921) using 2% acetocarmine stain. The meiotic chromosome configurations were also studied in each phase of division (metaphase, anaphase, telophase and pollen characters). The data collected for all the meiosis characters were recorded.

Results

The morphological characters and meiotic chromosome behaviors of two *Zea mays* L. cultivars were described in Table 1 to 2 and Figure 1 to 4.

Taxonomic Description

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

Annual erect herbs, monoecious; stems 230 – 280 cm high, solid, well-defined nodes and internodes, 13 – 18 jointed swollen nodes; internode 10 – 22 cm in length, the last node end with tassel. Leaves simple, alternate and distichous, exstipulate, sessile; blades linear-lanceolate, 37 – 102 cm long and 4.0 – 10.0 cm wide, the margin entire, hairy, the apex acuminates, scarcely strigose on both surfaces; ligule 0.5 – 1.0 cm long, auriculate. Male inflorescences or tassels terminal paniculate, 33 – 45 cm long, 22 – 33 branched. Female inflorescences or ears axillary, 2 to 3, series of paired spikelets in longitudinal rows, the rows usually even number, 12 – 16. 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. Pauk pauk pyaung ni

Plant height 239 – 249 cm; ear height 183 – 204 cm; jointed swollen nodes 17 – 18 and internodes 10 – 22 cm long. Leaf blades 37 – 99 cm long and 5.5 – 10.0 cm wide. Male inflorescences or tassels 33 – 38 cm long with 22 to 29 branches. Female inflorescences or ears 3 per plant; silk color pale yellow; ears 28 – 30 cm long and 15 – 17 cm in diameter; female florets arranged in 14 – 16 rows per ear; cobs diameter 10 – 13 cm; kernel purple in color.

Tasseling Period: 60 – 79 days

Outstanding characters of cv. Phu sar pyaung

Plant height 230 – 280 cm; ear height 149 – 217 cm; jointed swollen nodes 13 – 15 and internodes 14 – 19 cm long. Leaf blades 37 – 102 cm long and 4.0 – 9.5 cm wide. Male inflorescences or tassels 41 – 45 cm long with 26 to 33 branches. Female inflorescences or ears 2 – 3 one per plant; silk color red; ears 29 – 30 cm long and 14 – 18 cm in diameter; female florets arranged in 12 - 14 rows per ear; cobs diameter 12 – 14 cm; kernel pale white and pale purple in color.

Tasseling Period: 55 – 67 days

Meiotic characters

The chiasmata frequencies were calculated according to synapsis of chromosome arm at metaphase I. In *Z. mays* L. cv. Pauk pauk pyaung ni was observed the highest number of frequency of chiasmata (18.43 ± 1.25) than the cv. Phu sar pyaung (16.93 ± 1.53). The formulae of chromosome constitution were 0.05I + 1.35 oII + 8.38 cII + 0.15 III + 0.03 oIV + 0.03 cIV in *Z. mays* L. cv. Pauk pauk pyaung ni and 0.38 I + 2.15 oII + 7.18 cII + 0.23 III + 0.03 oIV + 0.03 cIV in cv. Phu sar pyaung as recorded in table 1.

It was observed that the normal diakinesis stages (2n = 20) was observed in all studied cultivars of *Zea mays* L. as shown in Figure 2. The metaphase chromosome behavior of the two *Z. mays* L. cultivars were described as the mean value of univalent, bivalent (ring, rod and total), trivalent, chain and ring quadrivalent, frequency of chiasmata and meiotic configuration in table 1. Among two *Zea mays* L. cultivars, the cv. Phu sar pyaung was possessed the high mean number of univalent chromosome (0.38 ± 0.59) than the cv. Pauk pauk pyaung ni (0.05 ± 0.20).

The maximum mean number of ring (8.38 ± 1.35) and total (9.73 ± 0.73) bivalent chromosomes was found in *Z. mays* L. cv. Pauk pauk pyaung ni, while the *Z. mays* L. cv. Phu sar pyaung was possessed the highest rod bivalent chromosome (2.15 ± 1.13). The cv. Phu sar pyaung was stated that the higher trivalent chromosome than the cv. Pauk pauk pyaung ni. The ranges of quadrivalent (chain, ring and total) were slightly different to each other in the two studied *Z. mays* L. cultivars (Table 1).

The anaphase I and telophase I chromosome behaviors of the two cultivars of *Z. mays* L. were described in Table 2 and Figure 2. The maximum mean number of laggard and bridge chromosomes at anaphase I and telophase I were found in *Z. mays* L. cv. Phu sar pyaung. In *Z. mays* L. cv. Pauk pauk pyaung ni was not occurred the laggard chromosome in anaphase I and bridge chromosome in telophase I, it possessed the lowest mean number of bridge chromosome in anaphase I and laggard chromosome in telophase I (Table 2).

In meiotic division II (Metaphase II, Anaphase II and Telophase II) analysis, synchronous chromosome segregation was found in two studied *Z. mays* L. cultivars (Figure 3). The normal and abnormal spore tetrads were also observed in two studied *Z. mays* L. cultivars as seen in table 2 and figure 4. The mean number of micronuclei at tetrad and abnormal pollen character of *Z. mays* L. cv. Pauk pauk pyaung ni was lower than the cv. Phu sar pyaung.

Table 1 Comparison on metaphase I characters of two cultivars of *Zea mays* L.

	cv. Pauk pauk pyaung ni $\overline{X}$ **± S. E**	**cv. Phyu sar pyaung** $\overline{X}$ **± S. E**
No. of Chromosome	20	20
No. of Cells Studied	60	60
Univalent	0.05 ± 0.20	0.38 ± 0.59
Rod Bivalent	1.35 ± 1.12	2.15 ± 1.13
Ring Bivalent	8.38 ± 1.35	7.18 ± 1.38
Total Bivalent	9.73 ± 0.73	9.33 ± 0.93
Trivalent	0.15 ± 0.60	0.23 ± 0.06
Ring Quadrivalent	0.03 ± 0.26	0.03 ± 0.26
Rod Quadrivalent	0.03 ± 0.26	0.03 ± 0.26
Total Quadrivalent	0.07 ± 0.36	0.06 ± 0.36
Frequency of Chiasmata	18.43 ± 1.25	16.93 ± 1.53
Meiotic configuration	0.05I + 1.35 oII + 8.38 cII + 0.15 III + 0.03 oIV + 0.03 cIV	0.38 I + 2.15 oII + 7.18 cII + 0.23 III + 0.03 oIV + 0.03 cIV

$\overline{X}$ = mean
S. E = Standard Error
I = univalent, oII = open bivalent, cII = closed bivalent, III= trivalent,
oII = open quadrivalent, cIV = ring quadrivalent

Table 2 Comparison on mean number of laggard, bridge at Anaphase I and Telophase I; Tetrad and pollen characters in two cultivars of *Zea mays* L.

	cv. Pauk Pauk Pyaung ni **X ± S. E**	**cv. Phyu sar pyaung** $\overline{X}$ **± S. E**
Laggard chromosome at anaphase I	-	0.17 ± 0.38
Bridge chromosome at anaphase I	0.10 ± 0.31	0.33 ± 0.48
Laggard chromosome at telophase I	0.03 ± 0.18	0.33 ± 0.48
Bridge chromosome at telophase I	-	0.07 ± 0.25
Micronuclei at tetrad	10.00 ± 2.83	23.00 ± 2.83
Normal Pollen Character	60.80 ± 4.02	55.00 ± 3.08
Abnormal Pollen Character	39.20 ± 4.02	45.00 ± 3.08

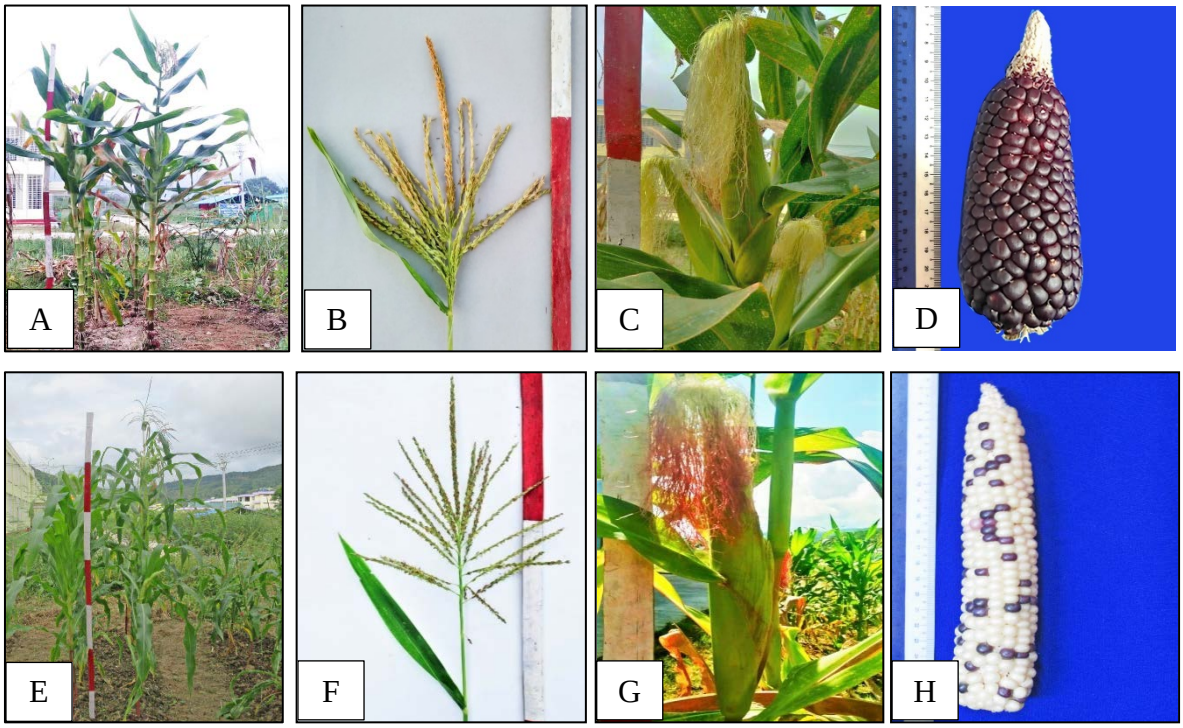

Figure 1 Morphological characters of *Zea mays* L. cv. Pauk pauk pyaung ni and Phu sar pyaung

A. Habit of cv. Pauk pauk pyaung ni
B. Tassel character of cv. Pauk pauk pyaung ni
C. Ear character of cv. Pauk pauk pyaung ni
D. Cob character of cv. Pauk pauk pyaung ni
E. Habit of cv. Phu sar pyaung
F. Tassel character of cv. Phu sar pyaung
G. Ear character of cv. Phu sar pyaung
H. Cob character of cv. Phu sar pyaung

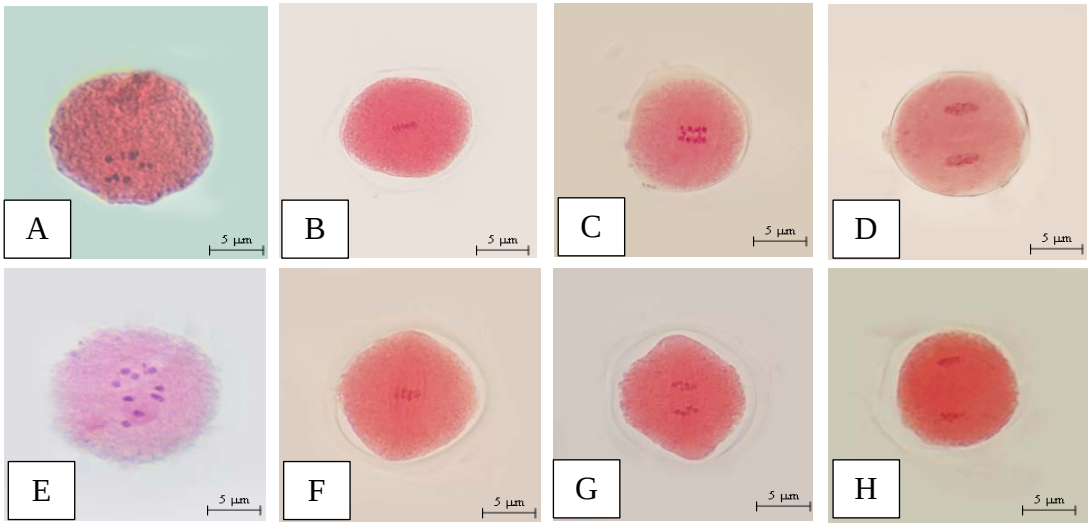

Figure 2 Diakinesis, Metaphase I, Anaphase I and Telophase I characters of *Zea mays* L. cv. Pauk pauk pyaung ni and Phu sar pyaung

A. Diakinesis character of cv. Pauk pauk pyaung ni

B. Metaphase I character of cv. Pauk pauk pyaung ni
C. Anaphase I character of cv. Pauk pauk pyaung ni
D. Telophase I character of cv. Pauk pauk pyaung ni
E. Diakinesis character of cv. Phu sar pyaung
F. Metaphase I character of cv. Phu sar pyaung
G. Telophase I character of cv. Phu sar pyaung
H. Telophase I character of cv. Phu sar pyaung

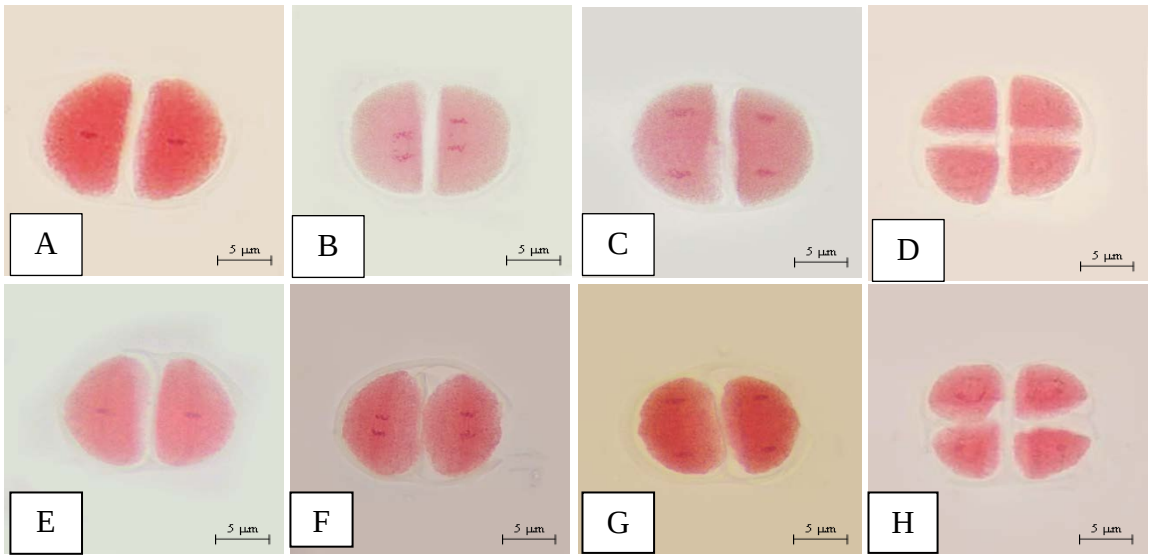

Figure 3 Metaphase II, Anaphase II, Telophase II and Tetrad characters of *Zea mays* L. cv. Pauk pauk pyaung ni and Phu sar pyaung

A. Metaphase II character of cv. Pauk pauk pyaung ni
B. Anaphase II character of cv. Pauk pauk pyaung ni
C. Telophase II character of cv. Pauk pauk pyaung ni
D. Tetrad character of cv. Pauk pauk pyaung ni
E. Metaphase II character of cv. Phu sar pyaung
F. Anaphase II character of cv. Phu sar pyaung
G. Telophase II character of cv. Phu sar pyaung
H. Tetrad character of cv. Phu sar pyaung

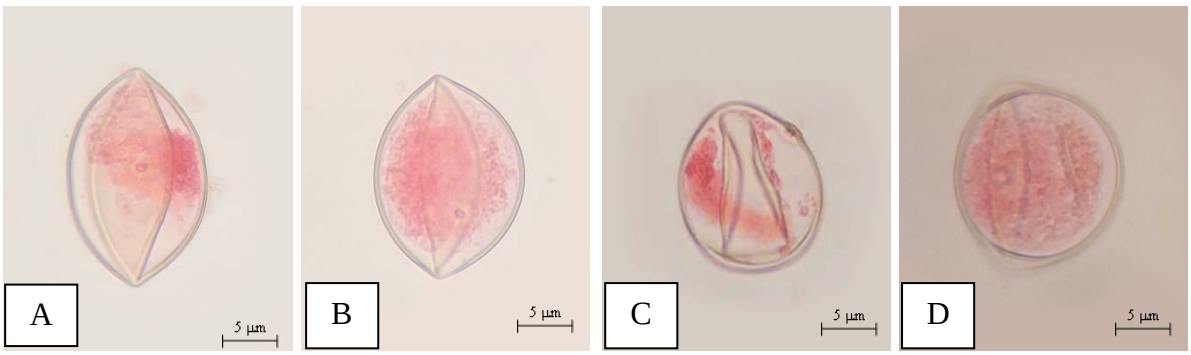

Figure 4 Normal and abnormal pollen characters of *Zea mays* L. cv. Pauk pauk pyaung ni and Phu sar pyaung

A. Normal pollen character of cv. Pauk pauk pyaung ni
B. Normal pollen character of cv. Phu sar pyaung
C. Abnormal pollen character of cv. Pauk pauk pyaung ni
D. Abnormal pollen character of cv. Phu sar pyaung

Disscusion and Conclusion

The morphology and meiotic chromosome characters of the two *Z. mays* L. cultivars were studied. The two studied *Z. mays* L. cultivars cv. Pauk pauk pyaung ni and Phu sar pyaung were slightly different in most morphological characters, while significantly different in silk and kernel color. These finding were agreement with (Rosemary, 2000), the different kernel colors yellow, red and purple are produced by the carotenoids or the anthocyanin pathway. White color, results from the lacks of pigments produced from either pathway.

In the meiotic behavior, chromosome number, meiotic stages, as well as abnormalities were studied. The chromosome number of two studied maize cultivars were 2n = 20 at diakinesis. This observation was agreement with Khah *et. al.* (2018), meiosis was found normal in the PMCs of *Zea mays* L. plants which showed regular 10 bivalents (2n = 20) at diakinesis. A varying range of various meiotic irregularities were observed during the separation and anaphase movement of the chromosome.

In univalent chromosome of two *Z. mays* L. cultivars, the *Z. mays* L. cv. Pauk pauk pyaung ni (0.05 ± 0.20) was significantly inferior to the cv. Phu sar pyaung (0.38 ± 0.59). Due to this condition of the cytological anomalies, the laggard and bridge chromosomes of the cv. Phu sar pyaung was observed in anaphase and telophase than the *Z. mays* L. cv. Pauk pauk pyaung ni. This observation was agreed with Khah & Verma (2017a), who stated that the chromosome clumping at metaphase sometimes led to their inability of bivalents to separate at anaphase, thus leading to the sticky bridges. The observed disturbed polarity might have occurred due to spindle disturbances and presence of high frequency of univalents. The chiasmata frequency of the cv. Phu sar pyaung (16.93 ± 1.53) was also lower than the cv. Pauk pauk pyaung ni (18.43 ± 1.25). This result was agreement with Sjödin (1970), who suggested that the presence of univalent chromosomes resulted in the discrease of chiasma frequency.

Although the *Z. mays* L. cv. Phu sar pyaung was possessed the high rod bivalent chromosome (2.15 ± 1.13), the cv. Pauk pauk pyaung ni was stated that the maximum ring (8.38 ± 1.35) and total bivalent chromosome (9.73 ± 0.73). Among two studied *Z. mays* L. cultivars, the mean number of normal pollen character in cv. Pauk pauk pyaung ni (60.80 ± 4.02) was higher than the cv. Phu sar pyaung (55.00 ± 3.08). This result was agreed with Sumner (2003), Khin Swe Lai (2010) and Chaw Su Lwin (2016) also stated that the cultivars were possessed the high ring bivalent and total bivalent chromosome number produced the high percentage of fertile pollen.

The meiotic abnormalities, formation of multivalents have been observed. The *Z. mays* L. cv. Phu sar pyaung was possessed the high number of trivalent chromosome (0.23 ± 0.06) than the cv. Pauk pauk pyaung ni (0.15 ± 0.60). The mean number of quadrivalent chromosome (ring, chain and total) was not significantly different between two cultivars. Risso-Pascotto *et. al.* (2005) proposed the meiotic process was typical of polyploids, with chromosomes associating in bi-, tri-, and quadrivalents. Precocious chromosome migration to the poles, laggards and micronucleus formation were found in both meiosis I and II, resulting in tetrads with micronuclei in some microspores. The frequency of abnormal pollen mitosis varied among flowers and also among inflorescences. All plants were equally affected. Sterile pollen grains resulted from this abnormal pollen development.

In *Z. mays* L. cv. Pauk pauk pyaung ni was not observed the laggard and bridge chromosome in anaphase I and telophase I. The *Z. mays* L. cv. Phu sar pyaung was possessed high mean number of the laggard and bridge chromosome in both anaphase I and telophase I. Therefore, the high mean number of micronuclei in tetrad (23.00 ± 2.83) and abnormal pollen

(45.00 ± 3.08) was also found in cv. Phu sar pyaung. This finding was agreement with Bajpai and Singh (2006) stated that the meiotic abnormalities which generally affect pollen viability have troubled sexual reproduction. In conclusion, the morphological character of the two studied maize cultivars was slightly different while in silk and kernel color were significantly different. The total bivalent, chiasmata frequency and pollen fertility of the *Z. mays* L.cv. Pauk pauk pyaung ni was superior. Therefore, the *Z. mays* L. cv. Pauk pauk pyaung ni should be selected for inbreed experiment for future researches.

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