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Viability of Local Corn (*Zea mays L.*) Seeds from North Central Timor Regency Treated with Colchicine

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Abstract

Background: Colchicine is a chemical mutagen widely used to increase the viability of a plant. Most of the people of the North Central Timor (TTU) Regency still depend on local agricultural products, so one of the crops cultivated during the rainy season is local corn. This study aimed to determine the viability of local maize seeds in the North Central Timor Regency and the appropriate colchicine concentration to increase local maize germination. **Methods:** This research uses an experimental method that gives colchicine treatment to 3 local corn varieties. The colchicine used was 0% (control), 40%, and 60%. The viability parameters observed were maximum growth potential (PTM), germination capacity (DB), and vigor index (IV). **Results:** showed that there were variations in the measurement of viability parameters observed both at maximum growth potential (PTM JBa 16,6%, JBu 35%, JKa 10%, JKu 8,33%), germination (DB 70%, JBu 81,66%, JKa 60%, JKu 61,66%) and vigor index (IV 68,33%, JBu 78,33%, JKa 63,33%, JKu 68,33%). **Conclusions:** the appropriate concentrations of colchicine to increase local corn germination were 40% and 60%, respectively. This can be seen in the viability parameters that show differences, namely the maximum growth potential (PTM) of flower corn with a colchicine concentration of 40%, which is 35%, the germination capacity (DB) of flower corn with a colchicine concentration of 60%, which is 90%, and the vigor index (IV) of flower corn. The concentration of colchicine 60% is 90%.

Keywords Colchicine; Local corn; Viability

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Introduction

Corn (*Zea mays L.*) is the Indonesian people's primary staple food source after rice. Because these plants contain good carbohydrates and protein, corn is also needed to develop the food and animal feed industry, apart from being consumed by humans (Directorate General of Food Crops, 2017). Along with increasing population growth, the food and feed industry development caused market demand for local corn to grow. This is because local corn can harvest faster, around 85 days. This continues to increase and is an opportunity for farmers to increase productivity in farming and produce better corn production (Bani, 2018).

North Central Timor District (TTU) is one of the districts located in the Province of NTT. Most of the people of TTU still depend on local agricultural products, so one of the crops cultivated during the rainy season is local corn. Productivity in NTT, especially TTU Regency, is dominated by Insana, Noemuti, East Miomafo, and West Miomafo Districts. According to research by Falo & Fallo (2016), corn has also been used as a home industry, which has been used as a tortilla or corn cracker industry. Kolo & Hutapea (2016) also illustrate that corn is used to make corn biscuits. Production and productivity of corn in 2013 with a planting area of 350 ha, production of 887 tons with a productivity of 2.53 t/ha (BPS Kab. TTU 2014), in 2014 there was an increase with a planting area of 700 ha, production of 1915 tons with a productivity of 2.73 t/ha (BPS TTU Regency, 2015). However, in 2015 it experienced a decline with a planting area of 500 ha, production of 1045 tonnes with, a productivity of 2.09 t/ha (BPS Kab. TTU, 2016).

Rikumahu (2012) revealed that seeds are a component that plays an essential role in determining the production yield of plants. In addition, Arif and Ratule (2015) also revealed that using quality seeds can reduce the risk of failure of farming to achieve high productivity and grow well in unfavorable conditions. Efforts to increase corn production are inseparable from the ability to absorb production technology, including using quality seeds that produce high quality and are free of pests.

Seed viability is the viability of the seed, which can be demonstrated through metabolic symptoms with growth symptoms. Germination is a measure of potential seed viability parameters. Seed germination is closely related to seed viability, and the number of seeds germinating from a batch of seeds is an index of seed viability. Seed vigor is the ability of roots to grow generally in sub-optimum field conditions and, above normal conditions, can rise simultaneously and quickly. Growth speed indicates the vigor or strength of seed growth because those growing fast can better deal with sub-optimal field conditions (Leisolo et al., 2013).

Colchicine is a mutagen that can affect plant growth and cause mutations in the number of chromosomes. Induction using colchicine is expected to improve the characteristics of corn plants, both qualitatively and quantitatively, especially in increasing crop productivity. Colchicine can cause some plants to produce larger flowers and tubers, although the effect is unpredictable. However, the results of polyploidization often show an increasing impact on the phenotypic properties of a plant (Glowacka et al., 2010). The colchicine treatment for the germination of corn seeds can show morphological deviations in corn plants by increasing shoot length, root length, plant height, number of leaves, and leaf width (Essel et al., 2015). It is expected that colchicine can influence the germination viability parameters of local maize plants.

Decreased seed viability or quality of plant seeds results in low vigor and poor plant growth and production. This study aimed to determine the viability of local corn seeds in the North Central Timor District and the appropriate concentration of colchicine to increase local maize germination.

Methods

Time and Place of Research

This research was conducted for six months, namely June-November 2021. This research consisted of 2 stages, namely the first stage of colchicine induction and the second stage of germination and observation of the viability of local corn sprouts, which was carried out at the Laboratory of the Faculty of Agriculture, University of Timor.

Tools and materials

The tools used in this study were stationary, Petri dishes, tweezers, pipettes, bottles for storing solutions, spatulas, cameras, calipers, and measuring cups. While the materials used in this study were lime white corn, stone white corn, yellow corn, flower corn, tissue, sprout paper, water, 40% and 60% colchicine, distilled water, and label paper.

Research methods

The method used in this study is an experimental method by giving treatment to each local corn. There were three treatments and five replications, so a total of 15 experimental units for each type of laboratory-scale maize (colchicine immersion and germination) (Table 1).

Research Stages

Preparation of Colchicine Solution

The colchicine solution is prepared by adding colchicine to distilled water according to a predetermined concentration, namely 0% without colchicine, 40%, and 60%. The 40% solution was prepared by weighing 0.4 g of colchicine dissolved in 100 mL of distilled water. A 60% solution weighed 0.6 g of colchicine dissolved in 100 mL of distilled water. Then, the solution is homogenized by stirring or shaking (Prasanna et al. 2012).

Germination of Corn Seeds

The germination method for local corn seeds in TTU Regency was colchicine induction. The corn seeds were taken in 0%, 40%, and 60% colchicine solution until shoots and roots appeared (1 day, equivalent to 24 hours). Next, the corn sprouts were dipped in distilled water and transferred to the planting medium (wetted cotton).

Table 1. Research Design

Corn varieties	Treatment and Replication					Number of corn seeds
Stone Corn (JBa)	P0B1	P1B2	P0B3	P1B4	P2B5	4
	P2B1	P0B2	P2B3	P2B4	P0B5	4
	P1B1	P2B2	P1B3	P0B4	P1B5	4
Flower Corn (JBu)	P2A1	P2A2	P1A3	P0A4	P2A5	4
	P0A1	P1A2	P0A3	P1A4	P1A5	4
	P1A1	P0A2	P2A3	P2A4	P0A5	4
Lime Corn (JKa)	P1C1	P0C2	P1C3	P0C4	P1C5	4
	P2C1	P2C2	P0C3	P2C4	P0C5	4
	P0C1	P1C2	P2C2	P1C4	P2C5	4
Yellow Corn (JKu)	P0D1	P1D2	P2D3	P0D4	P1D5	4
	P2D2	P0D2	P1D3	P2D4	P0D5	4
	P1D1	P2D2	P0D3	P1D4	P2D5	4

Index:
P0: Without colchicine 0% (control)
P1: Colchicine 40%
P2: Colchicine 60%
A1-A5; B1-B5; C1-C5; D1-D5: replication

Observation of Viability Parameters

a. Maximum Growth Potential (PTM) (%)

The maximum growth potential is obtained by calculating the number of seeds that grow normally or abnormally five days after germination (ISTA 2010). The formula calculates the maximum growth potential:

$$\text{PTM (\%)} = \frac{\sum Growing\ seeds}{\sum Planted\ seeds}\ x\ 100\%$$

b. Germination Power (DB) (%)

Germination was determined by calculating the number of seeds germinating within seven days using the ISTA formula (1972) in Kuswanto (1996).

$$\text{DB (\%)} = \frac{\sum \text{produced normal sprouts}}{\sum \text{germinated seeds}}\ \text{X 100 \%}$$

c. Vigor Index

Observation of the vigor index was carried out on the number of normal sprouts on the first count, namely on the 5th day (ISTA 2010)

$$\text{IV (\%)} = \frac{\Sigma \text{ normal sprouts on the first count}}{\Sigma \text{ Planted seeds}} x\ 100\ \%$$

Observational Variables

Parameters observed and measured on the morphology of maize plants (*Zea mays L*) included the number of seeds that germinated, the time of shoot emergence and shoot length, the time of root emergence, and root length. Growth parameter measurements were carried out in the laboratory.

Number of seeds germinated.

Observation of the Number of germinated seeds was carried out in the laboratory by calculating the growth potential of corn seeds, seed germination, seed growth rate, and seed vigor index.

Time of shoot emergence and shoot length

Observation of shoot emergence and measurement of shoot length was carried out on a laboratory scale, starting from the base of the stem to the tip of the highest shoot using a ruler. Measurements were made when the plants were three days after germination.

Root emergence time and root length

Observation of root growth time and measurement of plant root length was carried out using a caliper during germination in the Scala laboratory.

Growing potential

Observations on growth potential were obtained by counting the number of sprouts that grew normally and abnormally at 7 HST.

Corn seed germination

Germination was observed by counting the number of seeds germinating at 5 and 7 HST.

Vigor index

The vigor index was observed on the number of regular sprouts on the first count, namely on the 5th day.

The data analysis technique used is a descriptive analysis using a quantitative approach. Quantitative data are presented in tabular form using Microsoft Excel for growth potential viability data, corn seed germination power, and vigor index.

Result and Discussion

In general, maize has the same growth pattern, but the time interval between growth stages and the number of developed leaves differ. Corn growth can be grouped into three stages, namely the germination phase, the vegetative growth phase, and the reproductive phase (McWiliams et al., 2010). Corn seed germination occurs when the radicle emerges from the seed coat. Germination of corn seeds first absorbs water through a process of imbibition, and the seeds swell, followed by an increase in enzyme activity and high respiration. The initial change is largely in the catabolism of stored starch, fat, and protein. Sugars, fatty acids, and amino acids can be transported to the actively growing parts of the embryo.

At the start of germination, the coleorhiza extends through the pericarp. Then the radicle penetrates the coleorhiza. After the radicle appears, then the four lateral seminal roots also appear. The coleoptile covers the plumule at the same time or a moment later. The coleoptile is pushed up by the elongation of the mesocotyl, which pushes the coleoptile toward the soil surface. When the coleoptile tip emerges above the soil surface, the mesocotyl extension stops, and the plumule emerges from the coleoptile and penetrates the soil surface (McWilliams et al., 2010).

Maximum growth potential (PTM)

Growth potential is the percentage of emergence of sprouts which is calculated based on the number of seeds that germinate. Maximum growth potential (PTM) is one of the parameters of seed viability, the value of which indicates the condition of seed viability (Sutopo, 2010; Justice & Bass, 2010). According to Mugnisjah & Setiawan (2010), maximum growth potential indicates a seed can grow both normally and abnormally at certain limits.

Tabel 2. TTU Local Corn Maximum Growing Potential Data

No	Corn Varieties	Growing Seeds	Planted Seeds	PTM (%)
1.	JBa (control)	2	20	10
	JBa (40%)	2	20	10
	JBa (60%)	6	20	30
	Total	**10**	**60**	**16,6**
2.	JBu (control)	3	20	15
	JBu (40%)	7	20	35
	JBu (60%)	3	20	15
	Total	**13**	**60**	**21,66**
3.	JKa (control)	3	20	15
	JKa (40%)	1	20	5
	JKa (60%)	2	20	10
	Total	**6**	**60**	**10**
4.	JKu (control)	2	20	10
	JKu (40%)	2	20	10
	JKu (60%)	1	20	5
	Total	**5**	**60**	**8,33**

Based on this study, the percentage of maximum growth potential (PTM) was observed on the 3rd day after germination. The results showed that PTM for each local maize variety, namely the control treatment for rock corn and yellow corn, had a percentage of 10%, and flower corn and lime corn had a rate of 15%. Treatment of 40% colchicine concentration on rock corn and yellow corn has a percentage of 10%, flower corn 35%, and lime corn 5%. Treatment of 40% colchicine concentration on rock corn and yellow corn has a percentage of 10%, flower corn 35%, and lime corn 5%. Treatment of 60% colchicine concentration on stone corn varieties has a percentage of 30%, 15% flower corn, 10% lime corn, 5% yellow corn. The highest PTM was found in flower corn (JBu) with a 40% colchicine concentration treatment of 35% and the lowest maximum growth potential (PTM) was found in yellow corn (JKu) with a 60% colchicine concentration treatment of 5% (Table 2). According to Polhaupesssy (2014), the maximum growth potential is influenced by several factors, namely the supply of food in the seeds, the concentration is given, and the soaking time. The food reserves in the seeds are small, so plant growth is slow. This is due to the lack of O2, making it difficult for the seeds to germinate.

Based on the results of observations, it is known that the largest size of corn kernels is stone corn (JBa), and the smallest is flower corn (JBu). This greatly affects the imbibition of the seeds during immersion. The smaller the seed size and the softer the seed texture, the higher the maximum growth potential, and vice versa. The smaller the seed size, the softer the surface of the seed, and the faster the diffusion process so that the maximum growth potential also increases (Hertiningsih, 2014). This study's results align with Dewi & Pharmawati (2018) stated that the colchicine treatment affected marigold germination and that the sprouts treated with colchicine had a higher growth potential than the control sprouts. This was also noted by Putra & Soegianto (2019), that the 0.03% colchicine treatment on shallots with 10 hours of soaking time was 83%.

Germination Power (DB)

Germination is the number of seeds germinating from some seeds germinating on optimal growing media (laboratory conditions) at a specified time and is expressed in percent. The germination test is to germinate the seeds under conditions suitable for the needs of the seed germination, then calculate the ability of the roots to grow generally under optimum conditions (Sadjad, 2010).

Table 3. TTU Local Corn Germination Data

No	Corn Varieties	∑ Growing seeds	∑ Sprouted corn seeds	DB (%)
1.	JBa (control)	13	20	65
	JBa (40%)	12	20	60
	JBa (60%)	17	20	85
	Total	**42**	**60**	**70**
2.	JBu (control)	15	20	75
	JBu (40%)	16	20	80
	JBu (60%)	18	20	90
	Total	**49**	**60**	**81,66**
3.	JKa (control)	14	20	70
	JKa (40%)	12	20	60
	JKa (60%)	13	20	65
	Total	**39**	**60**	**60**
4.	JKu (control)	11	20	70
	JKu (40%)	10	20	50
	JKu (60%)	16	20	80
Total		**37**	**60**	**61,66**

Based on this study, DB observations were carried out on the 7th day after sprouting. The germination results for each variety of corn, namely in the control treatment, stone corn, the percentage was 65%, flower corn was 75%, lime corn, and yellow corn was 70%. In the treatment of 40% colchicine concentration, the percentage of rock corn was 60%, flower corn was 80%, lime corn was 60%, and yellow corn was 50%. Whereas in the treatment of 60% colchicine concentration, the percentage of rock corn varieties was 85%, 90% flower corn, 65% lime corn, and 80% yellow corn. The results showed that the percentage of germination varied with a range of 50% - 90%, the highest germination power in flower corn (JBu) with 60% colchicine concentration was 90%, and the lowest germination power in yellow corn (JKu) with 40% colchicine concentration was 50% (Table 3).

Artichart (2013) states that the germination standard classified as high for almost all seeds is> 80%. This research shows that rock corn (JBa) and flower corn (JBu) are included in the high DB category, each treated with 60% colchicine concentration. These results indicate that the higher the colchicine concentration, the higher the seed germination. However, Sofia (2010), in her research, stated that high colchicine applications could reduce the amount of crop production. This is due to the effect of colchicine preventing the arrangement of micro granules, causing the genome to double due to the short metaphase cell size. In addition, the low germination of seeds is caused by an imbibition process that is not the same in the seed, so the growth of seeds into normal sprouts is not the same (Ghangaokar & Kshirsagar, 2013).

Vigor Index (IV)

The vigor index is the ability of seeds to grow generally under field conditions and sub-optimum environments. The vigor index value is a value that can represent the speed of seed germination which indicates the source. It was further stated that vigor is several seed characteristics that distinguish average, rapid, and uniform growth and development of sprouts in a range of optimum and sub-optimal field conditions (Ilyas, 2015).

Based on this research, they calculated IV in the observation. The results of the vigor index for each variety of corn, namely in the control treatment, stone corn, the percentage was 60%, flower corn was 65%, lime corn was 70%, and yellow corn was 70%. In the treatment of 40% concentration of colchicine, rock corn, and lime corn, the percentage was 60%, and flower corn and yellow corn were 80%. Whereas in the treatment of 60% concentration of colchicine, rock corn, and yellow corn, the percentage was 55%, flower corn was 90%, and lime corn was 60%. The results showed that the percentage of germination vigor index varied with a range of 55% - 90%, the highest vigor index in flower corn (JBU) with 60% colchicine concentration was 90%, and the lowest vigor index in yellow corn (JKU) with 60% colchicine concentration was 55%. (Table 4).

Rusminet et al. (2011) stated that the standard germination of the seeds tested used gibberellins to produce healthy plants, and the sweet corn germination test provided a satisfactory vigor measure. This research shows that rock corn (JBa) and flower corn (JBu) are included in the high vigor index category, each treated with 60% colchicine concentration.

Table 4. TTU Local Corn Vigor Index Data

No.	Corn Varieties	**Sprouts on the count**	Planted seeds	IV (%)
1.	JBa (control)	12	20	60
	JBa (40%)	12	20	60
	JBa (60%)	17	20	55
	Total	**41**	**60**	**68,33**
2.	JBu (control)	13	20	65
	JBu (40%)	16	20	80
	JBu (60%)	18	20	90
	Total	**47**	**60**	**78,33**
3.	JKa (control)	14	20	70
	JKa (40%)	12	20	60
	JKa (60%)	12	20	60
	Total	**38**	**60**	**63,33**
4.	JKu (control)	14	20	70
	JKu (40%)	16	20	80
	JKu (60%)	11	20	55
	Total	**41**	**60**	**68,33**

This study found the highest vigor index in flower corn (JBu) with a concentration of 60% colchicine, namely 90%. This can affect the percentage of vigor index (IV) given with colchicine. The difference in the percentage of normal sprouts in each colchicine treatment group was between 80-90%, while the control treatment group was 65-70%—seed vigor. When the corn seed imbibition occurs in the seed, the colchicine liquid enters the source (diffusion). The diffusion process is the movement of particles from an environment with a high concentration to an environment with a low concentration (Yunita, 2010). Corn seeds have a lower water concentration than water in the Petri dish container, so the corn seeds will germinate faster when there is a liquid transfer.

Wistiani (2015) showed that garlic seeds (*Allium sativum. L.*) given colchicine at the right concentration could increase the growth viability index vigor because they can work with hormones that can stimulate plant growth. This is also the same as the research of Sartika & Basuki (2017), where the administration of colchicine at a concentration of 500 ppm to watermelon plants (scientific name) will positively impact the growth of viability index vigor. Herman et al. (2013) showed that soaking mung bean seeds in 0.06% colchicine solution for 24 hours produced tetraploid mung beans. Nofitahesti & Daryono (2016) stated that colchicine treatment with concentrations of 0.01% and 0.02% with a treatment duration of 10 hours affected the increase in the viability of the vigor index.

Appropriate Concentration of Colchicine to Increase the Viability of Local Corn (Zea mays L.) Sprouts

Colchicine is an alkaloid extracted from the seeds and tubers of *Colchicum autumnale L.* and is commonly used as a mutagen. This mutagen compound can inhibit the formation of spindle fibers, thereby inhibiting growth and even causing death (Damayanti et al., 2012). In contrast, Aili et al. (2016) reported that colchicine's effect greatly influences maize's germination parameters.

Based on this study, the appropriate colchicine concentration to increase local maize germination on the viability parameter can be seen in the measurement results, namely PTM/DB/IV. Some parameters that show differences in viability are the maximum growth potential (PTM) of cornflowers with a concentration of 40% colchicine, namely 35%, the germination power (DB) of maize flowers with a concentration of 60% colchicine, namely 90%, the vigor index (IV) of cornflowers with a concentration of colchicine 60%, namely 90%. This is to Kartasapoetra's (2003) research, which showed that the percentage of maximum growth potential was on corn pulut with a PTM range of 44-86%. Germination capacity on pulut corn with a DB range of 88-100%. Vigor index on pulut corn with a range IV 79-83%. High-quality seeds have more than 90% viability, and plants can grow normally under sub-optimum conditions and produce optimally. Good results are supported by environmental factors and food reserves in the seeds, which also support the seed germination process. Seeds with high viability indicate that the seed has sufficient food reserves in the endosperm, which are used as an energy source by the seed during germination.

Permanasari (2014) states that seeds with high vigor will have high viability, whereas seeds with high viability do not necessarily have high vigor. Archipelago et al. (2010) also stated that seeds with the highest germination power and growing strength depend on the food reserves contained in the seed. The concentration of colchicine 60% in this study increased the viability of TTU's local lagoons. Suryo (2007) states that the highest concentration of colchicine solution will inhibit the arrangement of spindle thread microtubules, inhibiting mitosis. Sundov et al. (2010) stated that colchicine would be provided with the protein tubulin to prevent spindle threads' formation. Separation of chromosomes that should occur at the anaphase stage of mitosis does not occur and causes the doubling of chromosomes without forming a cell wall.

Colchicine can also affect plant physiology, making plants appear bigger and stronger and increasing production. Giving colchicine with a high concentration and long soaking time will cause stunted plant growth, so effective attention and proper soaking time are needed. Mahyuni et al. (2015) stated that administering 0.50% colchicine concentration gave better morphological characteristics. The morphological properties of the plants appeared to be far greater than that of the control, which resulted from cell enlargement due to the addition of chromosomes due to colchicine administration. Treatment with various concentrations of colchicine can give differences in the viability of local maize (*Zea mays L.)*

Conclusions

The results showed that the colchicine treatment gave differences in growth potential (PTM), germination capacity (DB), and vigor index (IV) in local maize (*Zea mays L*.) TTU. The appropriate concentration of colchicine to increase the germination of local corn is 40% and 60%. This can be seen in the maximum growth potential (PTM), germination capacity (DB), and vigor index (IV). Parameters that show differences in viability are the full growth potential (PTM) of flower corn with 40% colchicine concentration (35%), germination power (DB) of 60% colchicine concentration of corn flower (90%), vigor index (IV) of flower corn concentration colchicine 60% i.e. (90%).

Declaration statement

The authors reported no potential conflict of interest.

References

Arief R., & Ratule, M. T. 2015. Strategi Penguatan Penangkaran Benih Jagung Berbasis Komunitas*. Prosiding Seminar Nasional Serealia*.516-524.

Atichart, P. 2013. Polyploid Induction by Colchicines Treatment and Plant Regeneration of Dendrobium chysotoxum. *Thai Journal of Agricultural Science*. 46(1): 59-63.

BPS Kab. TTU. 2014. Musi dalam angka 2014, Kefamenanu: Badan Pusat Statistik Kabupaten TTU.

BPS Kab. TTU. 2015. Musi dalam angka 2015, Kefamenanu: Badan Pusat Statistik Kabupaten TTU.

BPS Kab. TTU. 2016. Musi dalam angka 2016, Kefamenanu: Badan Pusat Statistik Kabupaten TTU.

BPS Provinsi Nusa Tenggara Timur.2015, Nusa Tenggara Timur Dalam Angka. Badan Pusat Statistik.NTT.

Bani P. W. 2018.Karakterisasi Fenotip dan Kekerabatan Varietas Jagung Lokal Kabupatn Timor Tengah Utara.Savana Cendana 3(3): 41-42.

Budiman, Haryanto. 2013. Budidaya Jagung Organik Varietas Baru Yang Kian Di Buru. Pustaka Baru Putra. Yogyakarta.206 hal.

Chaikam, V. And G. Mahuku. 2012. Chromosome Doubling of Maternal Haploids. Doubled Haploid Technology in Maize Breeding: Theory and Practice. P. 14-29

Damayanti, F., I. Roostika Dan Samsurianto.2012. Induksi Keragaman Somaklonal Tanaman Kantong Semar (Nepenthes mirobilis) Dengan Mutagen Kimia Kolkisin Secara in Vitro.Seminar Nasional 1X Pendidikan Biologi FKIP UNS: 583-588.

Dewi, I, A, R, P., Dan Made, P., 2018. Penggandaan Kromosom Marigold (Tagetes Erecta L.) Dengan Perlakuan Kolkisin. Majalah Ilmiah. *Biologi Biosfera: A Scientific Journal*. 35(1): 153-157. https://doi.org/10.20884/1.mib.2018.35.3.773

Ditjen Tanaman Pangan. 2017. Komoditas Jagung Indonesia Siap Swasembada di Tahun 2017. Newsletter Pusdatin Pusat Data Dan Sistem Informasi Pertanian.14 (151).

Essel, E., L. K. Asante and E, Laing. 2015. Effect of Colchine Treatment on Seed Germination, Plant Growth and Yield Traits of Cowpea (*Vigna Unguiculata* (L) Walp). *Canadian Journal of Pure and Applied Sciences.* 9 (3):3573-3576.

Fajrina, A., M. Idris., Mansyurdin dan N. Surya. 2012. Penggandaan Kromosaom Dan Pertumbuhan Somaklonal Andalas (*Morus macroura* Miq. Var Macroura) Yang Diperlakukan Dengan Kolkisin. *Jurnal Biologi Universitas Andalas*.1(1): 23-26. https://doi.org/10.25077/jbioua.1.1.%25p.2012

Falo, M. & Fallo, Y.M. 2016.Kajian Pendapatan Agroindustri Tortila di Kecamatan Insana Barat Kabupaten Timor Tengah Utara. *AGRIMOR*. 1(02):19-20.

Ghangaokar, N. M., Kshirsagar, A. D. 2013. Study of seed horne fungi of different legumes. Sci journal [Internet]. [diunduhpada 2015 mei 22]; 2(1):32-35. Tersedia pada: http:// sciencejournal. In /data/documents/TLS-2-1-8.Pdf.

Herman, Irma Natalina M dan Dewi Indriyani Roslim. 2013. Pengaruh Mutagen Kolkisin Pada Biji Kacang Hijau (vigna radiata L.) Terhadap Jumlah Kromosom dan Pertumbuhan.Jurusan Biologi FMIPA Universitas Riau.Pekanbaru. *BioETI*. 13-20.

Ilyas, S. 2015. Ilmu dan Teknologi Benih: Teori dan Hasil-hasil Penelitian. IPB Press.

International Seed Testing Association (ISTA). 2010. Seed Science and Technology. International Rules for Seed Testing. Zurich: International Seed Testing Association.

Justice, O.L. dan L.N. Bass. 2010. Prinsip dan Praktek Penyimpanan Benih. Raja Grafindo Persada. Jakarta.

Kolo, D. & Hutapea, A.N. 2016.Strategi Pengembangan Usaha Biskuit Jagung di Kelompok Wanita Tani Lestari Desa Subun Tua Lele, Kecamatan Insana Barat, Kabupaten Timor Tengah Utara. *AGRIMOR*. 1 (03): 42-45

Leisolo, M.K, J. Riry Dan E.A. Matatula. 2013. Pengujian Viabilitas Dan Vigor Benih Beberapa Jenis Tanaman Yang Beredar Di Pasaran Kota Ambon. *Jurnal Agrologia*. 2(1):1-9

Mahendra F. 2009. Sistem Agroforetri Dan Aplikasinya. Yogyakarta: Graha Ilmu.

Nura, S., A. K. Adamu, S. Mu'Azu, D. B. Dangora dan L. D. Fagwalawa. 2013. Morphological Characterization of Colchicine-induced Mutants in Sesame (*Sesamum indicum* L.). *Journal of Biological Sciences*. 13 (4): 277 – 282.

Nusantara AD, Kusuma C, Mansur I. 2010. Pemanfaatan vermikompos untuk produksi biomassa legum penutup tanah dan inokulum fungi mikoriza. Jurnal Ilmu-Ilmu pertanian Indonesia.12(1): 26-33.

Paeru, RH., & Dewi, TQ. 2017 Panduan Praktis Budidaya Jagung. Jakarta: Penebar Swadaya. Cetak 1.

Polhaupessy, S. 2014. Pengaruh Konsentrasi Giberelin dan lama perendaman terhadap perkecambahan biji sirsak (Anona muricata L). Biopendix. 1(1): 71-76.

Purwono, M.S. & Hartono, R. 2007.Bertanam Jagung Unggul. Penebar Swadaya. Jakarta.

Pratama, Y. 2015. Respon Tanaman Jagung (Zea Mays L.) Terhadap Kombinasi Pupuk Anorganik Dan Pupuk Bio-Slurry Padat. [Skripsi]. Fakultas Pertanian. Universitas Lampung. Lampung

Prasanna, B.M Vijay Chaikam and George Mahuku (eds). 2012. Doubled Haploid Technology in Maize Breeding. Theory and Practice. Mexico. D.F. CIMMYT. 24-29.

Putra K. Bagus., dan Soegianto A. 2019. Induksi Poliploidi Pada Bawang Merah (Allium sativum L.) dengan pemberian kolkisin. Jurnal Produksi Tanaman 7(6) 1053-1058.

Raza, H., M. Jaskani, M. M. Khan and T. A. Malik. 2003. In Vitro Induction of Polyploids in Watermelon and Estimation Based on DNA Content. International Journal of Africulture and Biology.5(3): 298-302.

Rikumahu, Vilma, Victa. J. Pongoh. dan J. M. Paulus. 2012.Perkecambahan Benih Jagung (Zea maysL.) Pada Berbagai Umur Panen Benih Dan Kelembaban Media Tanam. Eugenia. 18(3)

Rosida Mahyuni, Eva Sartini Bayu Girsang, Diana Sofia Hanafiah, 2015. Pengaruh Pemberian Kolkisin Terhadap Morfologi Dan Jumalh Kromosom Tanaman Binahong (*Anredera cordifolia* (TEN) Steenis). Jurnal Agroteknologi 4(1): 1815-1821.

Sadjad, S. 2010. *The Phylosophy of Seed*. Bogor (ID): IPB Pr.

Sundov, Z., Z Nincevicb, M. Defines- Gojanovicc, M. Glavina – Durdovc, I. Jukica N. Hulinand, And A. Toncika. 2010. Fatal Colchicines Poisoning by Accidental Ingestion of Meadow Saffron-Case Report.Forensic Sciences Internation.149: 253-256.

Suryo. 2007. Sitogenetika. Yogyakarta: Gadjah Mada University Press.

Shaban, M. 2013. Review on physiological aspects of seed deterioration. *International Journal of Agriculture Crop Science*. 6(11): 627-32.

Sutopo, L. 2010. Teknologi Benih. Edisi Revisi. Raja Grfindo Persada. Jakarta.

Umar, D.H. 2012. Pelatihan Metodologi Penelitian. Bogor. Modul.

Warisno. 2009. Jagung Hibrida. Yogyakarta. Kanisius

Wistiani, L. A. J. dan Pharmawati M. 2015.Induksi Mutasi Kromosom dengan Kolkisin pada Tanaman Kesuna Bali (*Alium sativum* Linn.) dan Analisis DNA dengan Marka RAPD. *Bioslogos*. 5 (1):18-25.

Yunita, Indah. 2010. Kajian Sensitivitas Membran Dari Kulit Buah Markisa Sebagai Fiter Minyak Jelantah Sawit. *Skripsi*.FMIPA-UNP Padang.

Zuhrah, A.N. Aini, dan T. Wardyati 2010. Respon Morfologi Tanaman Sedap Malam (*Polianthes tuberose* L. cv. Roro Anteng) terhadap pemberian colchine. *Buanasains.*10 (2): 153-158.