CELL BIOLOGY & DEVELOPMENT
Volume 2, Number 2, December 2018 E-ISSN: 2580-4499
Pages: 78-87 DOI: 10.13057/cellbioldev/v020205

Morphology and cytology of five soybean varieties (*Glycine max*) treated with phosphate fertilizer

DAMAR CIPTO DARSONO, NANDARIYAH♥, SUGIJONO
Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57 126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ♥email: nandar.suroso@yahoo.com

Manuscript received: 22 September 2018. Revision accepted: 30 December 2018.

Abstract. *Darsono DC, Nandariyah, Sugijono. 2018. Morphology and cytology of five soybean varieties (*Glycine max*) treated with phosphate fertilizer. Cell Biol Dev 2: 78-87.* The demand for soybeans (*Glycine max* (L.) Merrill) tends to increase. The first step to increasing soybean productivity is identifying the plant's character. This study aims to study plants' morphological and cytological characteristics (chromosome number) and determine the effect of phosphate fertilizer application on changes in plant morphological and cytological characteristics (chromosome number) in five soybean varieties. The research was carried out from April 2009 to March 2010. Observations of plant morphology were carried out at the Jumantono Dry Land Research and Development Center (*Pusat Penelitian dan Pengembangan Lahan Kering Jumantono*), Karanganyar, Central Java, Indonesia (07°37' latitude and 110°56' east longitude). The number of chromosomes was analyzed in the Laboratory of Plant Breeding, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, Central Java, Indonesia, and the Laboratory of Animal Anatomy, Faculty of Biology, Universitas Gadjah Mada, Yogyakarta, Indonesia. Plant morphology research was arranged factorially using a Completely Randomized Block Design (RAKL). The treatment factors were varieties (Argomulyo, Anjasmoro, Kaba, Sibayak, and Wilis) and doses of P fertilizer (0, 18, and 36 kg P_2O_5/ha (equivalent to 0, 50, and 100 kg SP-36/ha). Therefore, there were 15 treatment combinations, and each combination was repeated 3 times. The observation of the number of chromosomes used the squash method. Quantitative data were analyzed by Analysis of Variance (ANOVA), if significantly different, continued with Duncan's multiple distance test (DMRT) level of 5%. The qualitative analysis was analyzed and presented descriptively. The results showed that each of the five soybean varieties' morphological characteristics differed. Applying phosphate (P) fertilizer from a dose of 0, 18, or 36 kg P_2O_5/ha could affect plant morphology in the form of an increase in plant height, length of the main root, number of branch roots, length of stem internode, length of petiole, leaf area, and weight of 100 seeds in each soybean variety. The number of chromosomes in five soybean varieties is the same, namely 2n = 40. The application of phosphate (P) fertilizer did not affect the number of chromosomes in the five soybean varieties.

Keywords: Cytology, *Glycine max*, morphology, phosphate fertilizer, soybean

INTRODUCTION

Indonesia is a country that has large and fertile land as natural resources. Therefore, climatic conditions, temperature, and humidity that are suitable for the growing needs of staple food crops cause almost all food crops to grow relatively well. One food crop that is very important for the Indonesian population is soybean (*Glycine max* (L.) Merrill).

Soybeans have been known for a long time as one of the plant sources of vegetable protein. Soybean seeds can be processed into food and beverage ingredients, such as tempeh, soy sauce, tauco, bean sprouts, milk, and soy juice drinks. As a food ingredient, soybeans are very nutritious for growth and maintain the condition of body cells. Soybeans contain many elements and important food substances such as protein, fat, carbohydrates, etc. The nutritional value of 100 g of soybean seeds is 330 calories, 35% protein, 18% fat, 35% carbohydrates, and 8% water (Budiastuti et al. 1997).

At this time, the demand for soybeans tends to increase in line with the increase in population, per capita income, and public awareness of the healthy menu. However, the pace of demand still cannot be matched by the increase in soybean production rate, so Indonesia must import it. For example, the demand for soybeans in 2004 was 2.02 million tons. However, domestic production only reached 0.71 million tons, so to meet the needs, the government must import 1.31 million tons since only about 35% of the total needs can be fulfilled by domestic production itself (Swastika et al. 2008). Therefore, it is necessary to increase soybean production to meet soybean needs and reduce import dependency.

It is necessary to pay attention to several aspects of cultivation, especially proper fertilization, to increase the productivity of soybean plants and use superior varieties (Amir et al. 2015). Fertilizers have an important role in plant life, especially plant physiology. Physiological processes that take place optimally can encourage plants to respond to growth in appearance and high yields. One of the important macronutrients for soybean plants is phosphorus (P). Phosphorus plays an important role in growth and production because it can provide the energy needed for plant metabolic activities.

Each soybean variety has a different appearance, and it is it's characteristic. Therefore, as an initial step to increase soybean productivity, it is necessary to identify plant characteristics, especially the character of the variety to be cultivated. Identification of these characters can be made

genetically or morphologically. The genetic identification is useful to support the development of soybean plants, especially concerning plant breeding activities, both direct and indirect applications. The use of genetic information in plant breeding indirectly increases the knowledge of the genetic composition of a plant species and can be used directly to improve plant characteristics.

The morphological identification of soybean varieties is intended to identify the characteristics of soybean plants from their external appearance. Descriptions based on morphological characters can generally be used to determine the relationship between soybean varieties that can be seen directly because these morphological characteristics arise through the interaction between genetic traits and the environment in which the plant grows. The combination of genetic and morphological identification is expected to be useful for obtaining complete information about the nature and characteristics of soybean plants. These are useful in soybean production efforts to obtain optimal results.

The aims of this study were: (i) to study plant morphology and cytology characteristics (chromosome number) in five soybean varieties. (ii) to determine the effect of phosphate fertilizer application on changes in plant morphological and cytological characteristics (chromosome count) in five soybean varieties.

MATERIALS AND METHODS

Place and time of research

Research on plant morphology was carried out at the Dry Land Research and Development Center (*Pusat Penelitian dan Pengembangan Lahan Kering*), Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, located in Jumantono, Karanganyar, Central Java, Indonesia, with latosol soil types at positions 07°37 latitude and 110°56 east longitude and an altitude of 180 m above sea level. In addition, cytological research (chromosome count) was carried out at the Laboratory of Plant Breeding, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, and the Laboratory of Animal Anatomy, Faculty of Biology, Universitas Gadjah Mada, Yogyakarta, Indonesia. The research was conducted from April 2009 to March 2010.

Research material

The materials in this study included seeds (Argomulyo, Anjasmoro, Kaba, Sibayak, and Wilis varieties), fertilizer (Urea, SP-36, KCl), 1 N HCl solution, 2% aceto-orcein solution, Carnoy solution 2 (6 ethanol : 3 chloroform : 1 glacial acetic acid 45%), alcohol 96% and aquades.

Research tools

The tools in this research included a hoe, measuring tape, seed drill, nameplate, camera, tweezers, flacon, glass preparations, cover glass, light microscope, and photo-microscope.

Research design

The design used in the soybean plant morphology study was a Completely Randomized Block Design (CRBD), which consisted of two factors. The factor I: soybean variety (V), consists of 5 levels: (i) V1: Argomulyo variety, (ii), V2: Anjasmoro soybean, (iii) V3: Kaba variety, (iv) V4: Sibayak variety, (v) V5: Wilis variety. The factor II: dose of phosphate fertilizer (D), consists of 3 levels: (i) D0: 0 kg P_2O_5/ha or equivalent to 0 kg SP-36/ha, (ii) D1: 18 kg P_2O_5/ha or equivalent to 50 kg SP-36/ha, (iii) D2: 36 kg P_2O_5/ha or equivalent to 100 kg SP-36/ha. Based on the treatment of these two factors, 15 treatment combinations were obtained. Each treatment combination was repeated 3 times (as blocks) so that there were 45 treatment plots. Sampling was done by random sampling in each treatment, with 3 samples for each treatment plot.

Plant morphology

Land preparation

Land preparation aims to make the physical condition of the land lose and reduce weed populations. Land preparation is done by hoeing the land to be used for soybean cultivation, and then plots are made with a size of 1 m x 1.5 m.

Planting

Selected soybean seeds (5 varieties) were planted in planting holes with a spacing of 20 cm x 25 cm. Each planting hole is filled with 3-4 soybean seeds and then covered with soil.

Fertilization

Fertilizer for soybeans are: Urea 100 kg/ha, SP-36 according to treatment, namely 0; 50; and 100 kg/ha and KCl 100 kg/ha. The application of urea fertilizer was carried out in two stages at the beginning of the planting period with half the total dose. At the same time, the rest was given when the plants were 4 WAP. SP-36 and KCl fertilizers were applied at the beginning of planting.

Sprinkling

Water plays a very important role in the growth of soybean plants, from the beginning of growth to the period of pod filling. Watering is carried out until it reaches field capacity and starts 5-7 days after the seedlings grow. Subsequent irrigation is carried out when the soil looks dry.

Plant replacement and thinning

Plant replacement is done on plants that die or do not grow at age of one week after planting. Thinning was done at 3 WAP, leaving two plants for each hole.

Weeding

Plant weeding is carried out simultaneously with additional fertilization and according to the condition of the weed population around the plant.

Yield

Harvesting occurs when the plants are ready to harvest (depending on the variety), with 80% of the pod population evenly brownish yellow, the stems are dry, and some leaves have dried and fallen off. Harvest implementation at 80 DAP.

Observation

Observations were made visually covering the vegetative (roots, stems, leaves) and generative (flowers, fruit/pods, seeds) parts based on their morphological appearance. Observations on the roots, stems, leaves, and pods were conducted two weeks before harvest. Seed observation was carried out at harvest. At the same time, the observation for flowers was performed when soybean plants began to flower.

Cytology (chromosome number)

Material preparation

The material was taken from the meristematic root tip ± 5 mm. The root tip is used as a preparation material because it is the most meristem organ related to its function as a nutrient-seeking tool that always divides to move in search of nutrients (Setyawan and Sutikno 2000). Root cutting was carried out at 08.00-08.30.

Pre-treatment

Pre-treatment was carried out for the separation and decomposition of chromosome density, purification of the cytoplasm, and softening of the tissue (Gunarso 1988). Pre-treatment was carried out by immersing the material in distilled water for ± 24 hours at a temperature of 5-8°C.

Fixation

Fixation was done to eliminate the tissue without causing changes to the cell components (Gunarso 1988). Fixation was carried out using Carnoy 2 solution (6 ethanol: 3 chloroform: 1 glacial acetic acid 45%) and stored in the refrigerator for ± 24 hours, then washed gradually every 10 minutes in a row with 70% alcohol, 50% alcohol, and 30% alcohol and aquadest (distilled water).

Hydrolysis

According to Setyawan and Sutikno (2002), hydrolysis was carried out to obtain cells that were spread out in chromosomal observations by dissolving the middle lamella of meristematic cells with no strong attachment. Hydrolysis was performed by immersing soybean roots in 1 N HCl solution for 10 minutes at room temperature (±25^{o}C).

Washing

The hydrolyzed root tips were then washed with distilled water 3 times. The washing was intended to remove the influence of the previous treatment.

Coloring

Chromosome staining was carried out by immersing the material in a 2% aceto-orcein solution for ± 24 hours at a temperature of 5-10°C. Aceto-orcein is suitable for root tips because of its fast penetration and long-lasting storage (Setyawan and Sutikno, 2000).

Squashing

± 0.5 mm of the tip of the meristematic root was taken and placed on a glass slide. The material was dripped with 45% acetic acid, covered with a cover glass, and then squeezed with the thumb. This preparation was used for the observation of the number of chromosomes.

Observation

Chromosomes were observed using a lighted microscope. Observations were made at the prometaphase stage, which showed good distribution. Chromosomes at the prometaphase stage have a much longer size and a much clearer appearance than in other stages (Parjanto et al. 2003). The results were then photographed with a photo-microscope.

Observation variable

Plant characteristics (morphology)

Plant height (cm), roots (main root length (cm), number of lateral roots), stem (stem color, stem shape, number of internodes, internode length (cm), number of branches, hair color), leaves (compound leaf shape and arrangement, compound leaf stalk length (cm), leaf area (cm^2), leaf tip shape, leaf base shape, leaf attachment method, top leaf color, leaf structure system, hair color), flower (when flowers appear (DAP), color flowers, flower location, number of flowers/plants, pods, including pod color, pod length (cm), number of seeds/pod, number of pods/plant, hair color), seeds (seed coat color, seed shape, the weight of 100 seeds (grams).

Number of chromosomes (cytology)

Chromosomes that appeared on observation with a microscope were photographed, and the number of chromosomes could be counted from the printouts.

Data analysis

Observational data was divided into two types, namely qualitative data and quantitative data. First, qualitative data were analyzed and presented descriptively to identify the morphological characteristics of soybean plants and the number of chromosomes. Analysis of Variance (ANOVA) analyzed quantitative data, and if there was a significant difference, it was continued with Duncan's multiple distance test (DMRT) at the 5% level.

RESULTS AND DISCUSSION

This study was divided into two stages: morphological observations of soybean plants in the field and cytological observations (number of chromosomes) using material from soybeans germinated in the laboratory.

Plant morphology

The morphological characteristics of five soybean varieties can be seen in Table 1.

Argomulyo varieties

Argomulyo variety is a determinate type of soybean. This variety has an upright habitus with slightly woody stems with a plant height of 31.69-36.57 cm. The stem is cylindrical and green. The entire surface of the stem is covered with brown hairs. The stem has 2-4 branches. The

number of internodes on the main stem is 8-11, with an average internode length of 2.87-3.24 cm.

The root system of the Argomulyo variety is in the form of a taproot. The taproot (*radix primaria*) is a central root that continues to grow into a main root and branches into smaller roots and is often referred to as a branch root (*radix lateralis*) (Rukmana and Yuniarsih 1996). The main root has a length of 14.93-20.27 cm. The main root forms branches with a total of 18-26 branch roots.

The leaves on the Argomulyo variety (Figure 1) are compounds that are trifoliate (three leaflets), although sometimes there are leaves with four or more leaflets. The leaves are green with a compound petiole 9.83-15.85 cm long. The shape of the tip of the leaf (apex) is pointed (*acutus*). The leaf tip is called pointed if the two edges of the leaf tip on the right and left of the leaf venation gradually move upwards and their meeting at the top of the leaf tip forms an acute angle (<90°). The shape of the leaf base is rounded (*rotundatus*). Leaf venation is pinnate. The leaves were alternately attached to the right and left of the stem. There are brown hairs on the surface of the leaves. The Argomulyo variety has a leaf area of 188.7-335.9 cm^2.

The flower of the Argomulyo variety is shaped like a butterfly. Flowers are called butterflies because they have a crown consisting of 5 free crowns, but 2 of the crowns are usually united in the form of a lifeboat or boat. These two attached crowns are usually narrow and located at the bottom, called the keel. The one opposite the keel is called the flag, and the wing is between the two halves (Tjitrosoepomo 2007). The flowers are purple. Flowers grow in the axils of the leaves and the tips of the stems or branches. The number of flowers in one plant reaches 50-80 flowers. The Argomulyo variety is a short-lived type of soybean. This soybean begins to flower when the plant is 28 DAP and can be harvested from 75 DAP.

Soybeans of the Argomulyo variety are in the form of pods with one or more internodes due to false partitions. The leaves of the legume are covered with brown trichomes (feathers). Young pods are green in color, while ripe/dark green pods are dark brown. The color of the pod is influenced by the carotene and xanthophyll pigments, the color of the feathers, and the absence of anthocyanin pigments. The pod may contain 1-5 seeds, but most pods contain 2-3 seeds (Hidajat 1985). The pods have a length of 4.03-4.57 cm. The length of this pod is influenced by the number and size of seeds in the pod. Although the number of flowers per plant is quite large, about 20-80% experience loss (Caldwell 1973), so only a few can form pods. In this Argomulyo variety, the number of pods in one plant is 25-43.

The shape of seeds differs depending on the variety, which can be round, slightly flat, or ovoid (Rukmana and Yuniarsih 1996), but most of the seeds are ovoid/oval (Hidajat 1985). The seeds of this Argomulyo variety are oval, slightly flattened, and yellow. The seeds of the Argomulyo variety are large, with a weight of 100, reaching 15.5-17.28 g/100 seeds.

Anjasmoro varieties

Anjasmoro variety is a determinate type of soybean. This variety has an upright habitus with slightly woody stems with a plant height of 43-50.3 cm. The stem is cylindrical and green. The entire surface of the stem is covered with white hairs. Branched stems are of 2-4 branches. The number of internodes on the main stem is 10-13, with an average internode length of 3.39-4.06 cm.

The root system of the Anjasmoro variety is a taproot. The main root has a length of 20.43-26.5 cm. The main root forms branches with a total of 19-27 branch roots.

The leaves on the Anjasmoro variety are compounds that are trifoliate (three leaflets), although sometimes there are leaves with four or more leaflets. Green leaves with compound petiole 11.03-16.77 cm long. The shape of the leaf tip (*apex*) is blunt (*obtusus*). The leaf tip is called blunt if the leaf edge, which was originally still a bit far from the main leaf venation, quickly goes to a meeting point to form an obtuse angle (<90°). The shape of the leaf base is rounded (*rotundatus*). The leaf venation is pinnate. The way of attachment of leaves is alternately attached to the right and left of the stem. On the surface of soybean leaves, there are white hairs. The leaves of the Anjasmoro variety are among the widest when compared to other varieties, with a leaf area of 239.5-562.8 cm^2. Wide leaves allow sunlight absorption so that the photosynthesis process will be more effective.

The flower of the Anjasmoro variety is shaped like a butterfly and is purple. Flowers grow in the axils of the leaves and the ends of the stems or branches. The number of flowers in one plant reaches 64-91 flowers. The Anjasmoro variety begins to flower when the plant is 36 DAP and can be harvested from 82 DAP.

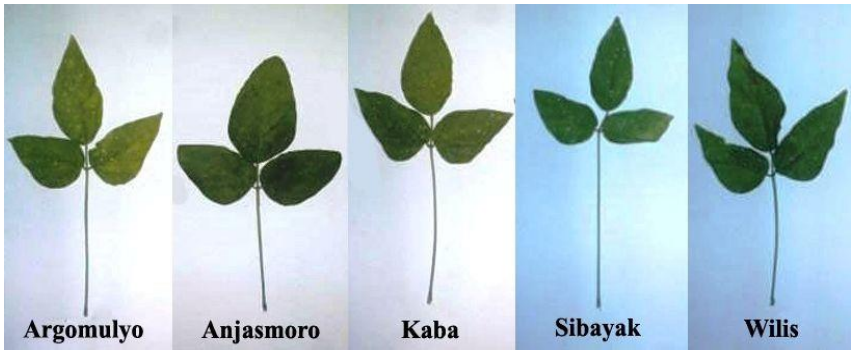


Figure 1. Soybean leaves

Table 1. Morphological characteristics of five soybean varieties

Morphological characteristics	Average value				
	Argomulyo	**Anjasmoro**	**Kaba**	**Sibayak**	**Wilis**
Plant height (cm)	32.6	44.53	45.73	56.67	44.59
Root					
Root length (cm)	16.36	20.69	19.91	21.54	19.46
Number of root branches	19.78	21.87	21.37	22.11	20.11
Stem					
Stem color	Green	Green	Green	Green	Green
Stem shape	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
Number of internodes	9.78	11.22	11.44	12.34	11.67
Internode length (cm)	2.94	3.51	3.73	4.45	3.73
Number of branches	2.11	3.22	2.89	4.45	2.66
Hair Color	Brown	White	Brown	Brown	Brown
Leaf					
Compound leaf shape and arrangement	Trifoliatus	Trifoliatus	Trifoliatus	Trifoliatus	Trifoliatus
Compound petiole length (cm)	11.14	13.38	15.04	15.60	14.89
Leaf area (cm^2)	293.3	342.31	179.58	231.11	242.68
Leaf tip shape	Pointed	Blunt	Pointed	Pointed	Pointed
Leaf base shape	Rounded	Rounded	Rounded	Rounded	Rounded
Leaf attachment	Right-left	Right-left	Right-left	Right-left	Right-left
Top sheet color	Green	Green	Green	Green	Green
Leaf venation	Pinnate	Pinnate	Pinnate	Pinnate	Pinnate
Hair Color	Brown	White	Brown	Brown	Brown
Flower					
Flower emergence time (DAP)	31.67	37	33.33	41	36
Flower color	Violet	Violet	Violet	Violet	Violet
Flower location	At the end of the stem and in the axils of the leaves	At the end of the stem and in the axils of the leaves	At the end of the stem and in the axils of the leaves	At the end of the stem and in the axils of the leaves	At the end of the stem and in the axils of the leaves
Number of flowers/plant	62.67	73.33	67.67	71	65.67
Pod					
Color of the ripe pod	Dark brown	Light brown	Brown	Light brown	Dark brown
Pod length (cm)	4.32	3.21	3.44	3.39	3.53
Number of seed/pod	2-3	2-3	2-3	2-3	2-3
Number of seed/plant	31.44	35.67	37	45.44	35.89
Hair Color	Dark brown	White	Brown	Brown	Dark brown
7. Seed					
Seed coat color	Yellow	Yellow	Yellow	Yellow	Yellow
Seed shape	Slightly flat oval	Slightly flat oval	Slightly oval	Oval	Slightly flat oval
100 seeds weight (gram)	14.76	14.89	10.89	11.43	11.45

Soybeans of the Anjasmoro variety are pod-shaped with young green pods and light brown when ripe. As on the surface of the stems and leaves, the surface of the pods is covered with white trichomes (feathers). Most pods contain 2-3 seeds. The pods are 3.05-3.57 cm long. The number of pods in one plant can reach 32-50 pieces.

The seeds of this Anjasmoro variety are oval, slightly flattened, and yellow. The seeds of the Anjasmoro variety are also large, with a weight of 100 seeds reaching 14.24-17.34 g/100 seeds.

Kaba varieties

The Kaba variety is a determinate type of soybean. This variety has an upright habitus with slightly woody stems with a plant height of 41.43-56.23 cm. The stem is cylindrical and green. The entire surface of the stem is covered with brown hairs. Branched stems with 2-3 branches. The number of segments on the main stem is 10-13, with an average length of 3.46-4.68 cm.

The root system of the Kaba variety is in the form of a taproot. The main root has a length of 15.97-24.8 cm. The main roots form 20-26 branches.

The leaves on the Kaba variety are compound-shaped and trifoliate (three leaflets), although sometimes there are leaves with four or more leaflets. The leaves are green with a compound petiole length of 13.8-16.57 cm. The shape of the tip of the leaf (*apex*) is pointed (*acutus*). The shape of the leaf base (base) is rounded (*rotundatus*). The leaf venation is pinnate. The way of attachment of leaves is alternately attached to the right and left of the stem. On the surface of soybean leaves, there are brown hairs. The leaves of the Kaba variety have a leaf area of 145.54-471.1 cm^2.

The Kaba variety's flower is shaped like a butterfly and purple. Flowers grow in the axils of the leaves and the ends of the stems or branches. The number of flowers in one plant reaches 59-89 flowers. The Kaba variety began to flower when the plant was 31 DAP and could be harvested from 81 DAP.

Soybeans of the Kaba variety are pod-shaped with young green pods and brown when ripe. The surface of the pod is covered with brown trichomes (hair). Most pods contain 2-3 seeds. The pods are 3.32-3.83 cm long. The number of pods in one plant is 27-63 pieces.

The seeds of this Kaba variety are slightly oval in shape and yellow in color. Soybean seeds of the Kaba variety were categorized as a medium, and the weight of 100 seeds was 10.74-12.81 g/100 seeds.

Sibayak varieties

Soybean of the Sibayak variety is a determinate type of soybean. This variety has an upright and large habitus (compared to the other 4 varieties). Slightly woody stems with a plant height of 53.7-66.1 cm. The stem is cylindrical and green. The entire surface of the stem is covered with brown hairs. Branched stems with 3-5 branches. The number of internodes on the main stem is 11-14, with an average internode length of 4.09-4.57 cm.

The root system of the Sibayak variety is a taproot. The main root has a length of 20.8-26.37 cm. The main root forms 19-26 branch roots.

The leaves on the Sibayak variety are compound in the form of trifoliatus (three leaflets), although sometimes there are leaves with four or more leaflets. The leaves are green with a compound petiole length of 13.63-17.87 cm. The shape of the tip of the leaf (*apex*) is pointed (*acutus*). The shape of the leaf base (base) is rounded (*rotundatus*). The leaf venation is Pinnate. The attachment of leaves is criss-cross, attached to the right and left of the stem. There are brown hairs on the surface of soybean leaves. The leaves of the Sibayak variety are wide, with a leaf area of 174.29-605.14 cm^2.

The flower of the Sibayak variety is shaped like a butterfly and is purple. Flowers grow in the axils of the leaves and the ends of the stems or branches. The number of flowers in one plant reaches 60-104 flowers. Sibayak soybean varieties began to flower when the plant was 37 DAP and could be harvested around 90 DAP.

The soybeans of the Sibayak variety are pod-shaped. Young pods are green, and ripe pods are brown. The surface of the pod is covered with brown trichomes (hairs). Most pods contain 2-3 seeds. The pods are 3.32-3.92 cm long. The number of pods in one plant can reach 38-58 pieces.

The seeds of the Sibayak variety are oval and yellow. Soybean seeds of the Sibayak variety are medium with a weight of 10.15-12.92 g/100 seeds.

Willis varieties

Soybean of the Wilis variety is a determinate type of soybean. This variety has an upright habitus with slightly woody stems with a plant height of 40.13-50.43 cm. The stem is cylindrical and green. The entire surface of the stem is covered with brown hairs. The stems have 2-4 branches. The number of internodes on the main stem is 10-14, with an average internode length of 3.29-4.24 cm.

The root system of the Wilis soybean variety is a taproot. The main root has a length of 20-27.63 cm. The main root forms branches with a total of 19-32 branch roots.

The leaves on the Wilis variety are compound and trifoliate, although sometimes there are leaves with four or more leaflets. The leaves are green with a compound petiole length of 13.33-18.55 cm. The shape of the tip of the leaf (*apex*) is pointed (*acutus*). The shape of the leaf base (base) is rounded (*rotundatus*). The leaf venation is pinnate. The attachment of leaves is criss-cross, attached to the right and left of the stem. There are brown hairs on the surface of soybean leaves. The leaves of the Wilis variety have a leaf area of 215.28-314.06 cm^2.

The soy flower of the Wilis variety is like a butterfly and is purple. Flowers grow in the axils of the leaves and the ends of the stems or branches. The number of flowers in one plant reaches 59-95 flowers. Soybeans of the Wilis variety began to flower when the plants were 33 DAP and could be harvested at around 85 DAP.

Soybeans of the Wilis variety are pod-shaped. Young pods are green, and ripe pods are brown. The surface of the pod is covered with brown trichomes (hair). Most pods contain 2-3 seeds. The pods are 3.31-3.86 cm long. The number of pods in one plant can reach 33-62 pieces.

The seeds of this Wilis variety are oval, slightly flattened, and yellow. Soybean seeds of the Wilis variety are medium with a weight of 100 seeds of 11.1-12.67 g.

The advantages of each variety can be identified based on the morphological characteristics of the Argomulyo, Anjasmoro, Kaba, Sibayak, and Wilis varieties. The Anjasmoro variety is a variety that tends to be superior to other varieties. This variety has more prominent characteristics, especially in the color of the hair (white), the shape of the tip of the leaf (blunt), the widest leaf area, the longest root length, the highest number of branch roots, and the largest seed size (14.89 g/100 seeds). This variety is a medium-aged soybean (can be harvested from 82 DAP) and can produce many pods.

The Sibayak variety is the variety with the highest plant habitus. This variety has many branches, producing the highest number of pods and medium-sized seeds (11.43 g/100 seeds). In addition, this variety has the longest lifespan because it can only be harvested from the age of 90 DAP.

Argomulyo variety is the variety with the shortest habitus and plant life. This variety can be harvested from the age of 75 DAP. This variety can produce large seeds (14.76 g/100 seeds) even though the number of produced pods is the least compared to other varieties.

Farmers commonly cultivate the Wilis variety. This variety can be harvested from the age of 85 DAP. This variety could produce many pods and medium-sized seeds (11.45 g/100 seeds).

The Kaba variety has a high plant habitus and a few branches. This variety is also commonly cultivated by farmers today. This variety can be harvested from the age of 81 DAP. This variety could produce many pods (second most after Sibayak). The seed size of the Kaba variety is medium (10.89 g/100 seeds) but smallest compared to other varieties.

Effect of phosphate fertilizer (PH) on plant morphology

The results showed that applying phosphate (P) fertilizer from a dose of 0.18 to 36 kg P_2O_5/ha can increase plant growth (the higher the dose, the higher the plant growth)(Figure 2). Applying P fertilizer to the soil will increase the P element in the soil so that the element can be sufficiently available for plants. Element P is the second essential macronutrient after N for plant growth. Elemental P is important because it is directly involved in almost all plant life processes. Still, this element is slightly available in the soil, especially in dry land undergoing advanced weathering (Sanyal et al. 1993), so it needs P element intake from outside.

Plant growth can be defined as an irreversible process of increasing plant size and volume. This growth can occur due to the activity of cell division, enlargement, and elongation. Cells require energy for these activities. Elemental P is needed in adenosine diphosphate (ADP) phosphorylation to adenosine triphosphate (ATP). ATP is an energy compound needed in plant metabolic processes. The presence of sufficient energy causes physiological processes in plants to take place optimally so that it can encourage plants to provide optimal growth responses as well. However, each variety has a different response to the dose of P fertilizer, depending on the genetic characteristics of each variety. Mursito (2003) suggests that different genotypes will show different appearances after interacting with certain environments.

Photosynthesis occurs in the leaf organs. Therefore, the plant's broad leaves will receive a lot of sunlight. Therefore, it can support the process of photosynthesis to run well. Photosynthesis results are distributed to the stems, leaves, and roots (Gardner et al. 1991) to support plant growth (vegetative phase). Based on the analysis results, it was found that increasing the dose of P fertilizer increased leaf area (Figures 3 and 4). Leaf area is also influenced by the genetic characteristics of each variety, especially leaf shape. An increase will follow the increase in leaf area in the length of the petiole because the petiole is the part of the leaf that supports the strands and is responsible for placing the leaf blades in such a position so that they can get as much sunlight as possible.

The stem, as the area of photosynthesis, utilizes the photosynthate for the lengthening and widening of the stem (Figure 5). Therefore, the increase in the length and width of the stem indirectly increases the number of stem segments, which in turn affects the length of the stem segments and the number of branches in the plant. The analysis showed that increasing the dose of P fertilizer could increase the length of the stem segments but did not affect the increase in the number of stem segments and branches in soybean plants. It is presumably because genetic factors of each variety influence the number of stem and branch segments in soybean plants.

The root is the part of the plant that functions to absorb water and nutrients from the soil to be transported through the stem to the leaves as photosynthetic material (Figures 6 and 7). Therefore, deep and broad roots will absorb more water and nutrients from the soil. The analysis showed that increasing the dose of P fertilizer increased the length of the main roots and the number of branch roots. Sutiyoso (2003) cit. Restiati (2006) stated that one of the functions of P is to bind solar energy and convert it into chemical energy, for example, in photosynthesis. Therefore, the provision of P elements can stimulate root growth so that large and strong roots will be formed.

The appearance of flowers marks the shift from the vegetative phase to the generative phase. One of the nutrients playing a very important role in flowering and fruiting in plants is the P element. P element can stimulate flowering in plants. After the plant enters the generative phase, the photosynthate results are more widely used to form generative organs (flowering, pod formation, and seed filling). The analysis showed that increasing the dose of P fertilizer had no significant effect on the flowering time and the number of flowers produced (Figure 8). However, applying P fertilizer to soybean plants could increase the number of flowers and accelerate the emergence of flowers in each soybean variety (the number of flowers was higher, and flowers appeared faster in soybeans fertilized with P).

Fruit formation is an important event in crop production. These processes are controlled by the environment, especially photoperiod and temperature, as well as by genetic or internal factors, particularly growth regulators, photosynthetic yield, and nutrient supply (Gardner et al. 1991). Irdiawan and Rahmi (2002) stated that the pod-filling phase requires full sunlight and good water content for some time, but too much water in the soil can interfere with the pod-filling process. The analysis showed that increasing the dose of P fertilizer had no significant effect on the number of pods produced by each soybean variety. Nevertheless, applying P fertilizer to soybean plants could still increase the pods in each soybean variety (Figure 9).

Inside the pod, there are generally 2-3 soybean seeds. Seeds are the goal of soybean cultivation. The shape and size of soybean seeds vary according to the genetic characteristics of the variety, ranging from small (about 7-9 g/100 seeds) to medium (10-13 g/100 seeds) to large (> 13 g/100 seeds) (Figure 10). The parameter of 100 seeds weight is generally used to determine the size and quality of seeds. The analysis showed that increasing the dose of P fertilizer could increase the weight of 100 seeds in each soybean variety. In addition, Wicks et al. (2004) stated that better plant growth accompanied by increased photosynthesis would increase the photosynthate supply to the seeds.

Cytology (chromosome number)

The results showed that each soybean variety had the same number of chromosomes, 2n = 40 (Figures 11-15). According to Bione et al. (2000), the genus Glycine, including several soybean cultivars, has a diploid number of chromosomes (2n = 2x = 40). The figures show that the size of the chromosomes is small, and there are quite a lot of them, so they often overlap in the observations. Species with many chromosomes have smaller chromosome sizes than species with fewer chromosomes (Suryo, 2003 cit. Sarasmiyarti 2008).

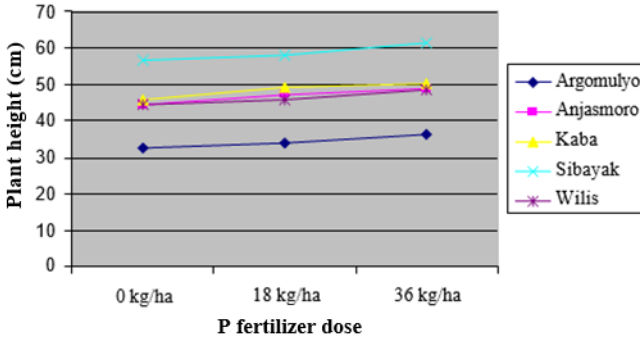


Figure 2. Effect of P fertilization on soybean plant height

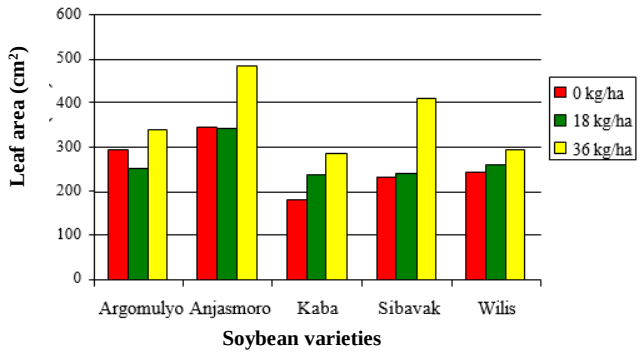


Figure 3. Effect of P fertilization on soybean leaf area

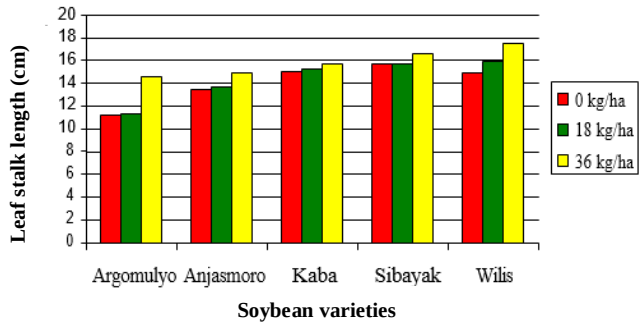


Figure 4. Effect of P fertilization on soybean leaf stalk length

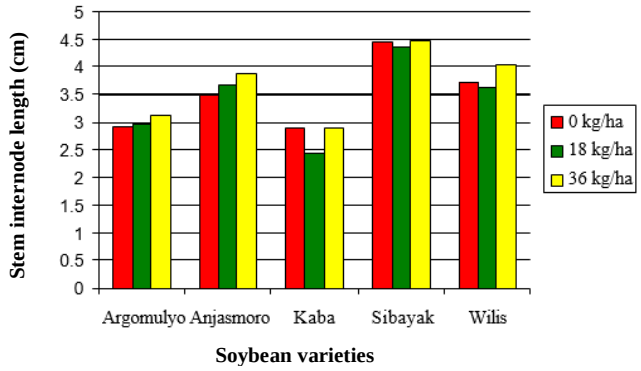


Figure 5. Effect of P fertilization on soybean stem internode length

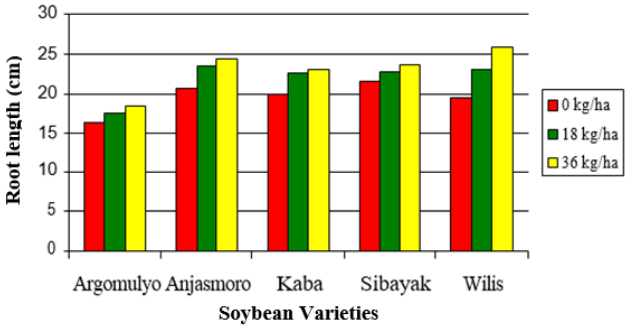


Figure 6. Effect of P fertilization on soybean root length

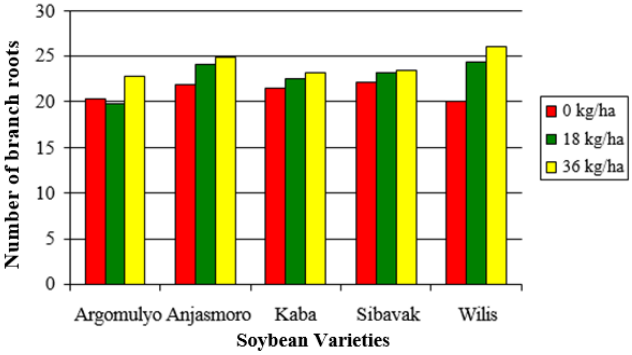


Figure 7. Effect of P fertilization on the number of soybean branch roots

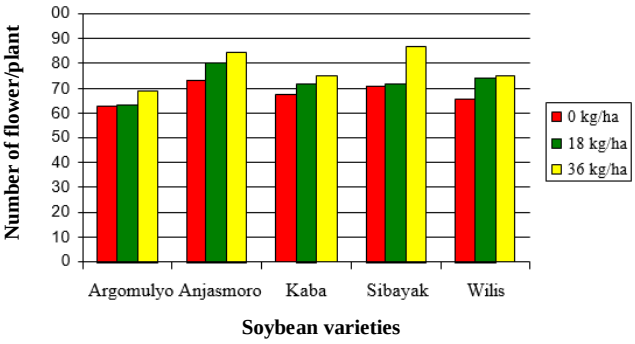


Figure 8. Effect of P fertilization on the emergence of soybean flowers

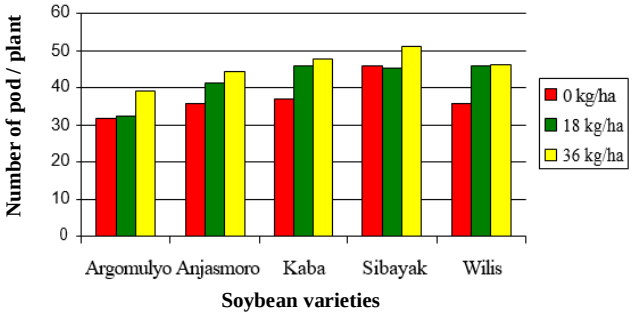


Figure 9. Effect of P fertilization on the number of soybean pod

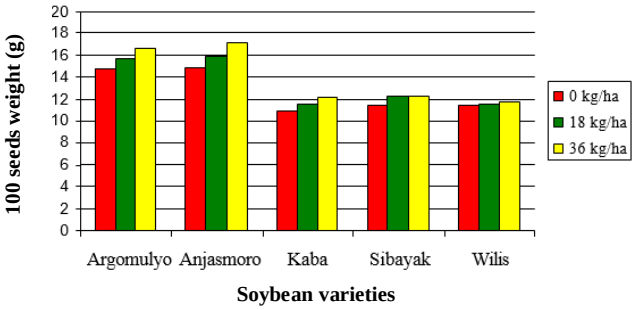
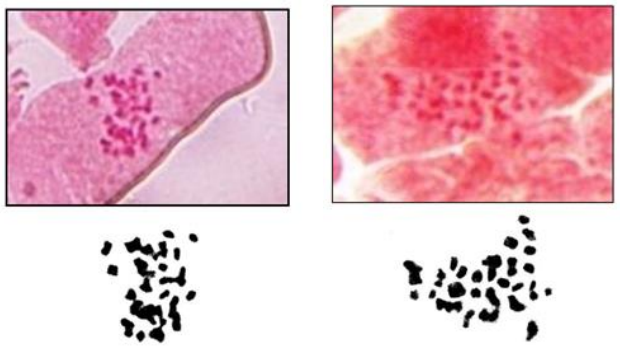
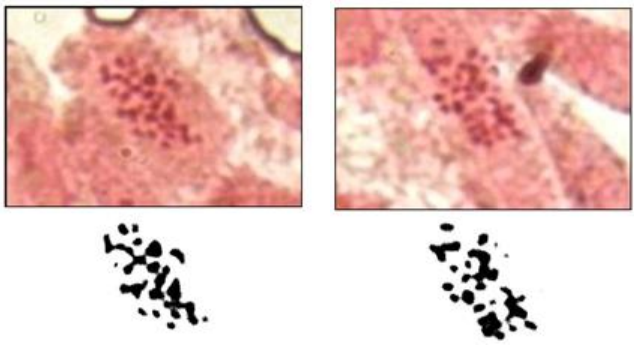


Figure 10. Effect of P fertilization on the weight of 100 soybean seeds



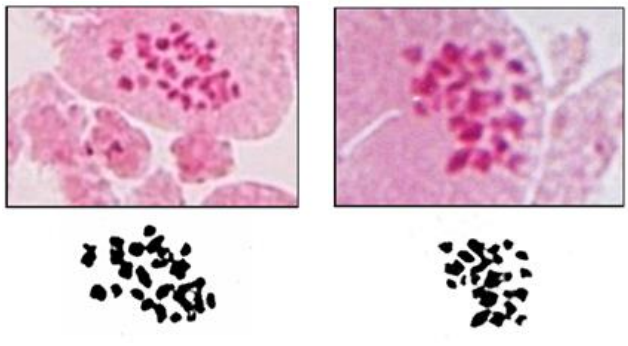
A **B**

Figure 11. Chromosomes of Argomulyo soybean variety. A. Without P fertilizer application, B. With P fertilizer application



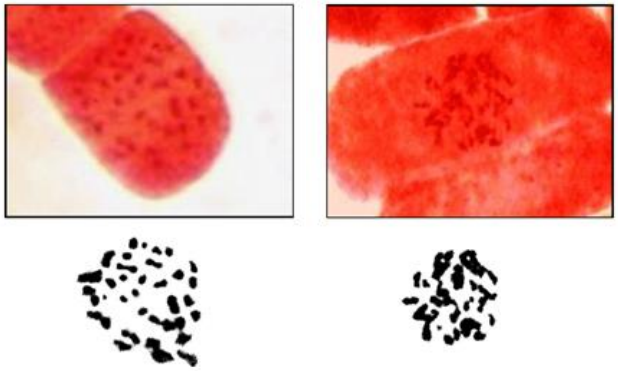
A **B**

Figure 12. Chromosomes of Anjasmoro soybean variety. A. Without P fertilizer application, B. With P fertilizer application



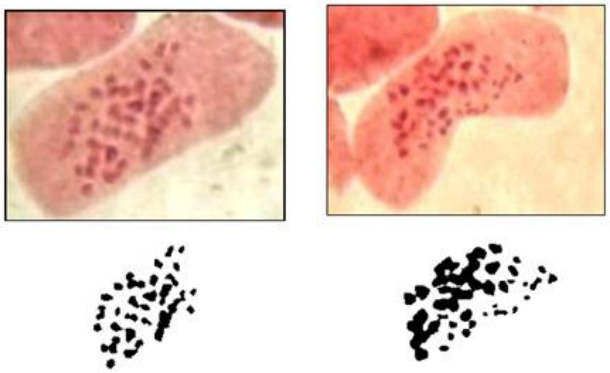
A **B**

Figure 13. Chromosomes of Kaba soybean variety. A. Without P fertilizer application, B. With P fertilizer application



A **B**

Figure 14. Chromosomes of the Sibayak soybean variety



A **B**

Figure 15. Chromosomes of Wilis soybean variety. A. Without P fertilizer application, B. With P fertilizer application

The study also showed no difference in the number of chromosomes between the five soybean varieties in the treatment without P fertilizer application and with P fertilizer application (the application of P fertilizer did not affect the chromosome number of each treatment). It shows that environmental factors do not affect the genetic characteristics of an individual, according to Johansen (1911) cit. Heddy (1990), the coinage of the term genotype was to designate basic traits that have not been affected by environmental factors, and the term phenotype was to designate visible traits.

Based on the research, it can be seen: (i) the morphological characteristics of the five soybean varieties are different in each variety; (ii) application of phosphate (P) fertilizer from a dose of 0, 18, or 36 kg P_2O_5/ha can affect plant morphology such as an increase in plant height, root length, number of branch roots, stem internode length, petiole length, leaf area, and weight at each of 100 seeds in each soybean variety; (iii) the number of chromosomes in the five soybean varieties is the same, namely 2n = 40; (iv) the application of phosphate (P) fertilizer did not affect the number of chromosomes in the five soybean varieties.

REFERENCES

Amir B, Indradewa D, Putra ETS. 2015. Hubungan bintil akar dan aktivitas nitrat reduktase dengan serapan N pada beberapa kultivar kedelai (*Glycine max*). Pros Sem Nas Masy Biodiv Indon 1: 1132-1135. DOI: 10.13057/psnmbi/m010. [Indonesian]

Bione NCP, Pagliarini MS, de Toledo JFF. 2000. Meiotic behavior of several Brazilian soybean varieties. J Genet Mol Biol 23: 705-711. DOI: 10.1590/S1415-47572000000300022.

Budiastuti, Sumarno, Harjanti S, Sugiyono, Trijono. 1997. Kesesuaian pemberian air dan defoliasi pada tanaman kedelai (*Glycine max* L. Merrill) varietas wilis dan lokon. Caraka Tani 13: 1-8. [Indonesian]

Caldwell BE. 1973. Soybean: Improvement, Production and Uses. American Society of Agronomy, Inc., Wisconsin.

Gardner FP, Seedrce RB, Mitchell RL. 1991. Fisiologi Tanaman Budidaya. Universitas Indonesia Press, Jakarta. [Indonesian]

Gunarso W. 1988. Sitogenetika. Institut Pertanian Bogor, Bogor. [Indonesian].

Heddy S. 1990. Biologi Pertanian. Rajawali Pers, Jakarta. [Indonesian]

Hidajat OO. 1985. Morfologi tanaman kedelai. In: Atmaja SS, Ismunadji M, Sumarno, Syam M, Yuswadi SO, Manurung (eds). Kedelai. Pusat Penelitian dan Pengembangan Tanaman Pangan, Bogor. [Indonesian]

Irdiawan R, Rahmi. 2002. Pengaruh jarak tanam dan pemberian bokhasi pupuk kandang ayam terhadap pertumbuhan dan hasil kacang tanah (*Arachis hypogaea* L.). J Agrifor 1 (2): 31-36. [Indonesian]

Mursito D. 2003. Heritabilitas dan sidik lintas karakter fenotipik beberapa galur kedelai (*Glycine max* (L.) Merrill). Agrosains 6 (2): 58-63. [Indonesian]

Parjanto, Moeljopawiro S, Artama WT, Purwantoro A. 2003. Kariotipe kromosom salak. Zuriat 14 (2): 21-28. DOI: 10.24198/zuriat.v14i2.6789. [Indonesian]

Restiati S. 2006. Pengaruh Macam dan Konsentrasi Pupuk Cair terhadap Pertumbuhan dan Perkembangan Bibit Anggrek Bulan (*Phalaenopsis* sogo Chamba "yellow" *Phalaenopsis* I-Hsin sun flower) Secara Hidroponik. [Skripsi]. Fakultas Pertanian, Universitas Sebelas Maret, Surakarta. [Indonesian]

Rukmana R, Yuniarsih Y. 1996. Kedelai Budidaya dan Pasca Panen. Kanisius, Yogyakarta. [Indonesian]

Sanyal SK, De Datta SK, Chan PY. 1993. Phosphate sorption-desorption behaviour of some aciditic soils of South and Southeast Asia. Soil Sei Soc Am J 57: 937-945. DOI: 10.2136/sssaj1993.03615995005700040011x.

Sarasmiyarti A. 2008. Analisis Sitogenetika Tanaman Manggis (*Garcinia mangostana* L.) Jogorogo. [Skripsi] Fakultas Pertanian, Universitas Sebelas Maret, Surakarta. [Indonesian]

Setyawan AD, Sutikno. 2000. Karyotipe kromosom pada *Allium sativum* L.(bawang putih) dan *Pisum Sativum* L (kacang kapri). BioSmart 2 (1): 20-27.

Swastika DKS, Marwoto, Simatupang P. 2008. Pengembangan Kedelai dan Kebijakan Penelitian di Indonesia. http://pse.litbang.deptan.go.id. [Indonesian]

Tjitrosoepomo G. 2007. Morfologi Tumbuhan. Universitas Gadjah Mada Press, Yogyakarta. [Indonesian]

Wicks GA, Crutcfield DA, Burnside OC. 2004. Influence of wheat (*Triticum aestivum*) straw mulch and metalachlor on corn (*Zea mays*) growth and yield. Weed Sci 42: 141-147. DOI: 10.1017/S0043174500084307.