THE EFFECTS OF DIFFERENT RATES OF POTASSIUM WITH ORGANIC FERTILIZERS ON THEGROWTH, YIELD AND EATINGQUALITY OF MAIZE IN BRIS SOIL

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ABSTRACT

This study conducted at the net house of Faculty of Sustainable Agriculture, University Malaysia Sabah, Sandakan. The objective of this study was to compare the effect of incorporated of organic and inorganic fertilizers on growth, yield and eating quality of the local yellow glutinous maize (*Zea mays ceratina Kulesh*). Biochar and chicken manure, Urea, Triple Single Phosphate (TSP), and Muriate of Potash (MOP)) and BRIS soil were used in this experiment. Four treatments were used namely treatment 1 (control, 120:60:60 NPK), 2 (120:60:30 NPK + organic fertilizers), 3(120:60:90 + organic fertilizers) and 4 (120:60:120 NPK + organic fertilizers). Each treatment applied different rates of potassium but same rate of others organic and inorganic fertilizers except treatment without organic fertilizers. The experimental design was Completely Randomized Design (CRD) with five replications. Data on plant height and numbers of leaf were recorded every one week. Parameters for yield components such as length of the cob, weight of the cob with and without husks, circumference of the cob, number of kernels, 100 grains fresh weight, 100 grains dry weight and sweetness of the corn were taken after harvesting. Nitrogen, hydrogen and carbon analysis also carried out by used of CHN machine. After that, results were analyzed using SAS and the treatment means were compared by Least Significance Difference (LSD) test at 5 % significant level. In this study, treatment 3 which was the treatment with adequate organic and inorganic had the positive effects on the plant height, circumference of the cob, number of grains, fresh weight of 100 grains, dry weight of 100 grains and sweetness of the maize although this treatment did not showed good effects to others parameters. Therefore, treatment 3 can be considered as the better treatment to improve growth, yield and eating quality to the maize.

KESAN BERBEZA KADAR KALIUM DENGAN BAJA ORGANIK TERHADAP PERTUMBUHAN, HASIL DAN MAKAN KUALITI JAGUNG DALAM TANAH BRIS

ABSTRAK

Kajian ini dijalankan di rumah kalis serangga Fakulti Pertanian Lestari, Universiti Malaysia Sabah, Sandakan. Objektif kajian ini adalah untuk membandingkan kesan penambahan baja organik dan bukan organik kepada pertumbuhan, hasil dan kualiti makan jagung serbuk kuning tempatan (Zea mays ceratina Kulesh). Biochar dan baja ayam, Urea, Triple Single Phosphate (TSP), dan Muriate of Potash (MOP)) dan tanah BRIS digunakan dalam eksperimen ini. Empat rawatan digunakan iaitu rawatan 1 (kawalan, 120: 60: 60 NPK), 2 (120: 60: 30 NPK + baja organik), 3 (120: 60: 90 + baja organik) dan 4 (120: 60: 120 NPK + baja organik). Setiap rawatan menggunakan kadar kalium yang berbeza tetapi kadar lain yang lain adalah baja organik dan tidak organik kecuali rawatan tanpa baja organik. Reka bentuk eksperimen adalah Rancangan Rawak Secara Rawak (CRD) dengan lima ulangan. Data ketinggian tumbuhan dan bilangan daun dicatatkan setiap minggu. Parameter bagi komponen hasil seperti panjang tongkol, berat tongkol dengan dan tanpa sekam, lingkar tongkol, bilangan biji, 100 biji berat segar, 100 biji kering dan manis jagung diambil selepas penuaian. Analisis nitrogen, hidrogen dan karbon juga dilakukan dengan menggunakan mesin CHN. Selepas itu, keputusan telah dianalisis dengan menggunakan SAS dan kaedah rawatan dibandingkan dengan Ujian Pencapaian Penting (LSD) di tahap 5%. Dalam kajian ini, rawatan 3 yang merupakan rawatan dengan organik dan bukan organik yang mencukupi mempunyai kesan positif pada ketinggian tumbuhan, lilitan tongkol, bilangan bijirin, berat segar 100 butir, berat kering 100 butir dan manis jagung walaupun rawatan ini tidak menunjukkan kesan yang baik kepada parameter lain. Oleh itu, rawatan 3 boleh dianggap sebagai rawatan yang lebih baik untuk meningkatkan pertumbuhan, hasil dan pemakanan yang berkualiti kepada jagung.

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LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

ANOVA	Analysis of variance
BRIS soil	Beach Ridges Interspersed With Scales
C	Carbon
cm	Centimeter
CEC	Cation Exchange Capacity
EC	Electrical Conductivity
FAO	Food and Agriculture Organization of United Nations
g	Gram
LSD	Least Significance Differences
MOP	Moriate of Potash
N	Nitrogen
P	Phosphorus
pH	Potential of Hydrogen
K	Potassium
R	Replicates
TSP	Triple Super Phosphate

CHAPTER 1

INTRODUCTION

1.1 Background

Maize is the third most important crop after wheat and rice in Asia. The third largest planted crop is maize which is after rice and wheat (Abdolreza Abbassian, 2006). Maize, rice and wheat which are provided 30% and above of food calories of more than 4.5 billion people in 94 developing countries (FAO, 2016). Around 100 million hectares of maize is produced in 125 developing countries and one of the most crops has been growth in 75 countries (FAOSTAT, 2015). Other than that, maize always acts as feeding crops to the livestock also an important food staple. Of course, maize has used for industrial purposes such as manufacturing ethanol and food processing (Abdolreza Abbassian, 2006).

Based on data from the Department of Statistics Malaysia, the maize imports was increased 38.69% which was 432,351 mt in November 2015. Based on the high requirements of maize crops, Malaysia becomes the largest maize importer in Southeast Asia, because of limited production of corn in the country. But the annual consumption of maize at 3.4- 3.6 million mt per year, and it is mainly for the feed industry (Alexis Gan, Geetha Narayanasmy, 2016). Although production of maize keeps on increasing, the food supply for the market in the Malaysia still insufficient. Importation from others countries is still needed, the imported maize mainly from China, Australia, Burma, Thailand and Argentina. From now on to 2025, the requirements of maize for the population will be doubled. In 2025, maize will become the greatest crops that produce in worldwide especially in the developing countries (FAO, 2016).

Glutinous maize is one of the waxy maize which is scientifically known as *Zea mays ceratina Kulesh*. Glutinous maize is the maize with entire amylopectin, in contrast with common maize with approximately 78% amylopectin and 22% amylase (Panda, 2010). Amylopectin is a starch that can be break up the intermolecular bonds of starch molecules when presence of water or high temperature to produce sticky starch. Other than that, amylopectin starch has lower tendency retrograde compared to others corn species, thus more viscosity stable. Glutinous maize less consume by human but it always acts as raw material for textile, paper sizing agents and corn oil.

Potassium is one of the important elements that is used for the quality control of the maize to ensure optimum quality of the product (IPI, 2013). There are two main functions of the potassium. Firstly, potassium is used for activation of enzymes to carry out metabolic activities such as sugar and protein production. Secondly, potassium maintains the water content and turgor of the cells, it helps to proceed the photosynthesis process more efficiency and the movement of the sugars from the photosynthesis to storage organs. It also helps in the development of roots for more efficient in uptake nutrients from the soil.

Chicken manure is the waste products and residues that excrete by the chickens, it can change the biological, chemical and physiological properties of soil by improving soil structural quality, soil water holding capacity, soil infiltration, soil organism biodiversity and soil nutrient availability (Alexandra, 2005). According to Usman (2013), maize plants that have been treated with different organic materials can provide the sustainable way of improving soil quality and increasing the crop yields. Organic manure that applied in long term can make the soil become lower bulk density, higher porosity, porous and buffering capacities (Edmeades, 2003).

Nowadays, improvement of sandy soil becomes an important mission that has to be solved. Organic and inorganic inputs are required to improve the soil fertility and increase the production of crops (Ngetich *et al*, 2012). Biochar is an organic material that decomposes by high temperature, used for improves soil physical properties, fertility, biological activities and crop productivity. Biochar with many pores that can retain soil water to prevent dehydrated and neutralizes acidic soil with its base nature, also used for fertilizer holding in the soil to prevent it leaching by rainfall or watering. According to Zhang *et al* (2010), maize that planted on carbon poor calcareous soil with biochar and without N fertilization increased the yields while the N fertilization only enhanced the yields of maize.

1.2 Justification

Glutinous maize is unique compared to others maize variety because it is starchy and less sweetness. High amylopectin content for the glutinous maize makes it becomes waxy which is suitable for food products, used as a thickener and stabilizer to improve the uniformity, stability and texture in the food products. Other than that, it also makes a good adhesive which is suitable for adhesive products. But, glutinous maize is not preferred indirect consumption because it has low eating quality, lack of sweetness. However, the lower production and quality of glutinous maize compared to sweet maize which caused the glutinous maize has lower demand than other varieties.

Therefore, this study was to improve the growth, yield and eating quality of the maize by using incorporated organic and inorganic fertilizer. Potassium is the important fertilizer for improving the quality of maize because it helps to enhance translocation of sugars and starch and aids in photosynthesis and food formation to produce grains that rich in starch and sugar content. Organic fertilizers, chicken manure and biochar are used in this study to increase the quality and quantity of the maize. Organic fertilizers work in a different way. Chicken manure which increases the biological activities in the decomposition process, hold and retain water in the soil and influence the soil PH and electrical conductivity (EC). Biochar is the carbon-rich solid products from rice husks had been burned in an oxygen-limited environment. Biochar has more biologically and chemically stable compare to others organic and inorganic fertilizers. It always has a potential to enhance soil health and productivity. The incorporation of organic and inorganic fertilizers in optimum rate will get the better result in maize plants compared to a single type of fertilizer application.

Other than that, Bris soil used in this study for planting glutinous maize with incorporated organic and inorganic fertilizers, they will help to apply an optimum rate of fertilizers to the plant. The balance rate of the organic and inorganic fertilizers can avoid any deterioration of soil by excess inorganic fertilizers. And the quality and fertility of the soil can be improved for maize production. This also reduces the cost of inorganic fertilizer and reduces the pollution by the inorganic fertilizer.

This study was appropriate and useful because it will contribute to increasing knowledge to the better understanding of the effects of different fertilizers namely potassium, biochar and chicken manure on the growth, yield and eating quality.

1.3 Objectives

1. To evaluate the effects of different rates of potassium incorporated with organic fertilizers on the growth, yield and eating quality of yellow local glutinous maize planted on Bris soil

2 To evaluate the effects of different rate of potassium incorporated with organic fertilizers (biochar and chicken manure) on Bris soil.

1.4 Hypothesis

H_0: There is no significant difference on the growth, yield and eating quality of local yellow local glutinous maize between different fertilizers on Bris soil.

H_1: There is significant difference on the growth, yield and eating quality of local yellow local glutinous maize between different fertilizers on Bris soil.

H_0 : There is no significant difference the effects of different rate of potassium incorporated with organic fertilizers (biochar and chicken manure) on Bris soil.

H_1 : There is significant difference the effects of different rate of potassium incorporated with organic fertilizers (biochar and chicken manure) on Bris soil.

CHAPTER 2

LITERATURE REVIEW

2.1 Glutinous Maize

2.1.1 History of the Maize

Based on the hypothesis from the Paul Mangelsdorf and his colleague Robert Reeves in the late 1930s, the origin of the maize was domesticated from unknown wild maize. There were three parts of the hypothesis which are progenitor of the maize was the extinct or undiscovered wild maize species that came from South America, mixed of the maize and *Tripsacum* (another genus of grasses) to become the teosinate offspring and *Tripsacum* chromosomes had contaminated by the maize germplasm. The maize was domesticated from the teosinate through artificial selection by ancient population and mutation occurred to transform teosinate into maize (Mangelsdorf and Reeves, 1939).

There were many arguments about the geographical origin of the maize. Mexico and Central America which were the countries considered as the origins of the postulated places, where the origin of the teosinte grows and formed the maize plants. But the first mention of the crop on the record was on the 5 November 1492, when the Columbus reached the American mainland and found the maize samples at the Island of Cuba (Panda, 2010). In Europe, maize was introduced in Spain after Columbus returned from his second voyage and the plant was first grown as a garden curiosity. Later on, it spread from Spain to southern France and Italy. In India, the maize introduced by Portuguese during seventeenth century, and then spread to China and others country.

Figure 2.1: Changes in the *Z.mays* lineage over time
Source: Keith, 2001;

2.2 Taxonomy of Glutinous Maize

Waxy maize is a type of maize which also known as *Zea mays L. Var.ceratina Kulesh,* which was origin from China. It is an important vegetables crop in Asian countries and it is also used as raw materials for the food industries and for the special products of the wet milling starch industry for textile and paper sizing and corn oil. The endosperm looks waxy adhesive and for textile and proper sizing. Waxy maize is the maize with high contents of starch level, its kernels almost contains amylopectin starch. This genus of this Zea belongs to the tribe Andropogoneae in the subfamily Panicoideae in the family Poaceae (USDA, 2005, Australia Government).

Table 2.1 Scientific classification of the glutinous maize

Scientific classification	
Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Lilipsida
Subclass	Commelinidae
Order	Cyperales
Family	Poaceae
Genus	*Zea L.*
Species	*Zea mays L. Var.ceratina Kulesh*

Source: USDA, 2013

2.3 Botanical Description of Maize

Maize which is the plant belongs to the family of Gramineae, which also belonging to the tribe, Tripsarceae (Maydeae). The genus Zea, is monotypic and is represented by the single species Zea mays, which is of great economic importance (Rao, 1983). Maize is 2-3 meters tall plant with a solid single stem with 15 to 20 numbers of nodes and internodes, 3-4 cm in diameter each. The base of the maize plants are short and thick, but become longer and thinner at the top of the plants (Willy, 2010).

2. 3.1 Leaf

The height of the maize plant may grow 1-4m (3 to 13 feet) with leaf blades 50 to 90 cm (19 to 35 cm) long. For the leaves, they arise from the nodes and alternately on opposite on the stalk (Willy V.,2010). Each maize plant has 10-20 numbers of leaves and grows opposite sides of the maize. Each leaf consists of a thin, flat, long, narrow and expanded blade with a definite mid rib and smaller veins and a thicker, more rigid sheath. The sheath attached above of the nodes which surrounds the internodes. The leaf is supported by a prominent mid-rib along its entire length. Stomata occur on the both side of the leaf and on the entire surface of the leaf. The maize plants will rapidly absorb water during moist conditions and lose the turgid of the cells quickly by evaporation during dry conditions because of the upper surface motor are present and occur parallel and in row between the stomata (Sapkota, 2012).

2. 3.2 Stem

The stems are erect, conventionally 2-3 meters in height with many nodes and casting off-flag leaves at every nodes, the internodes can be reached 20-30 centimetres. In general, the maize stem ranges in 1.5 to 3 m. The stem is cylindrical, solid filled with pith and is clearly divided into nodes and internodes. The average of the internodes of the maize is around 14, but normally from 8 to 21 internodes (Panda, 2010). The internodes directly below the first four leaves do not lengthen, whereas those below sixth, seventh, and eighth leaves lengthen to approximately 25, 50 and 90mm respectively (Sapkota, 2012).

2.3.3 Shoot System

The primary shoot of the maize is initiated and generated from a single apical meristem during embryogenesis (Panda, 2010). Shoot system which includes stem, leaves and inflorescence. There are 5 to 6 vegetative phytomers initiated from shoot apical meristem before the seed matures and another 10 to 20 vegetative phytomers after germination and then produces the male inflorescence, tassel and female inflorescence, ear.

2. 3.4 Root System

Maize plants are composed of three types of root which are seminal, adventitious roots and aerial roots. The root length of maize plants can be reached around 2.0 or even longer. Seminal roots which are the first roots that grow out from the plants, also known as temporary roots which will be replaced by the permanent adventitious roots. Seminal roots which include of radicle and number of lateral roots which arise at the base of the first node of the stem under soil surface just above the scutellar node (Hochholdinger,2009). In the beginning, celeorhiza is pushed through the seed coat and reaches the soil surface, the adventitious roots emerge between the scutellum and the first internode and replace the seminal roots. Adventitious roots grow out from the crown which at the end of the mesocotyl will penetrate deeper into the soil to get moisture and nutrients. Beside, the aerial roots which also known as "prop" or "brace' are from the second to fourth nodes above the soil surface which help in keeping the plant upright and prevent lodging (Panda, 2010).

2. 3.5 Inflorescence

An inflorescence of the male and female (cobs or ears) are borne at the apex of condensed, lateral branches are borne from leaf axils, the apex of the stem ends in the tassel. The male (staminate) inflorescence which is a loose panicle produces pairs of free spikelets each enclosing a fertile and a sterile floret. For the female (pistillate) inflorescence which is a spike that can produce a pair of spikelets on the surface of highly condensed rachis. The female part is covered by several layers of leaves and they will only emergence of the pale yellow silks from the leaf whorl at the end of the ear. The silks are the elongated stigma that look like hairs initially and turn green or purple in colour. Each of the female spikelets encloses two fertile florests, one of the ovaries will mature into a maize kernel once sexually fertilized by wind-blown pollen (Millind and Isha, 2013).

2. 3.6 Tassel

The tassel is a branched inflorescence. It consists of a central spike (rachis) and about 10-50 lateral branches. There are many paired spikelets which are pedicellate and sessile occur around the centre of spike (Freeling, 1996). There are 2 florets, the development of upper floret is about 2-3 days ahead of the lower floret measured at the anthesis. For each of the floret covers with a pair of thin scale which are lemma and palea. Lemma which is a part that near to the glume and palea locates opposite to the lemma, also between the two florets. For each floret presents three anthers, there is two of them located to the palea and the third is located near to the lemma and located flanked by two lodigules. (Panda,2010). At the anthesis, the anthers will become swell and bend downward to transmit the pollens from the opening to the female part, ear. This process also known as pollination, with the help of pollinator or wind.

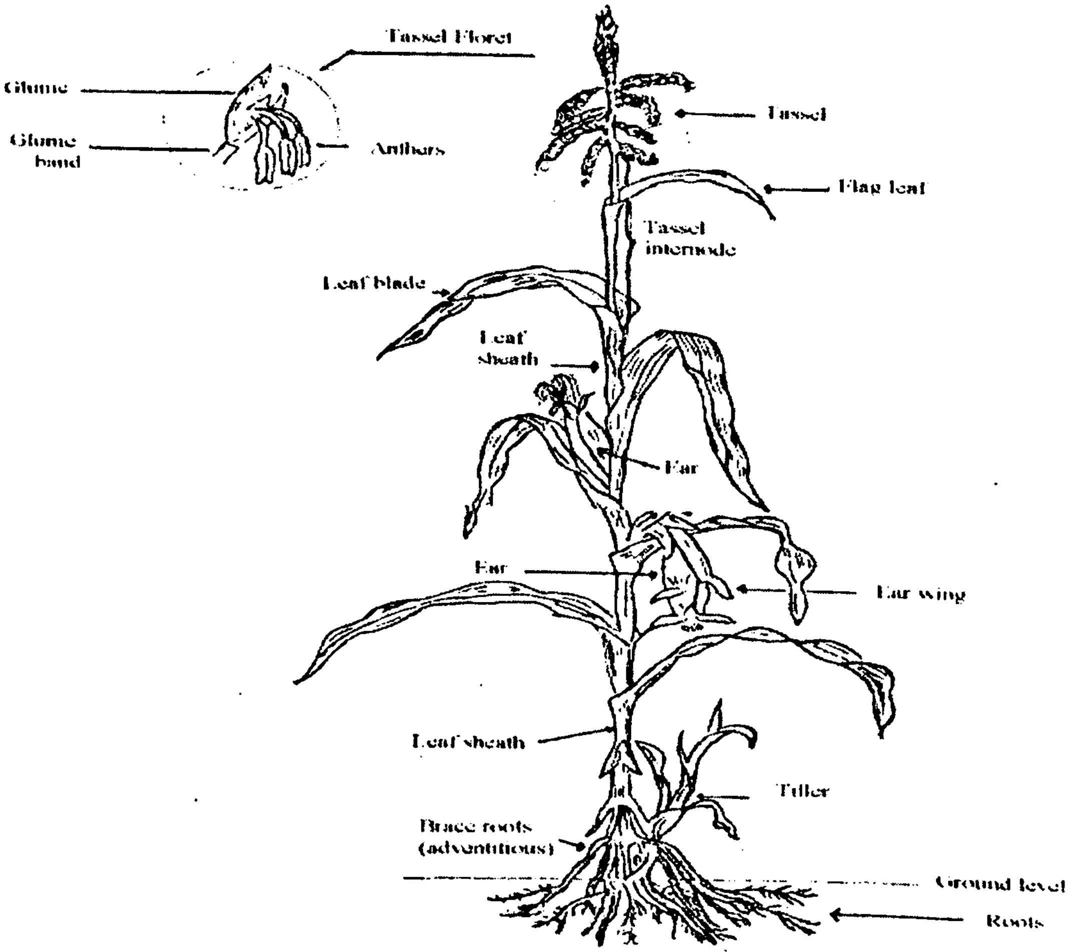

Figure 2.1: Corn Plant with Tassel Floret
Source: CFIA, 2015

2. 3.7 Ear

The ear will be grown under the casting off flag –leaves and close to the stem. The ears are tightly covered by several layers of leaves and they are female inflorescences. The ear contains one or several axillary buds that can be formed kernels. Around 8-14 leaves which known as husks and a prophyll are covered each of the axillary buds. Cob is thick axis that forms on the ear without lateral branches. For the central spike of tassel in that it produces multiple rows of paired spikelets. (Panda,2010).The ear of corn will be showed after pale yellow silks emergence from the leaf whorl at the end of the ear, which is the stigma and style of the female part organs. The silks look like hair which will be green in colour at first and then turn red or yellow later. And the silks are brown in colour when the fruits are ready for harvesting.

2.3.8 Kernel or Caryopsis

Kernel is the fruit of maize, it consists of an endosperm, embryo, a pericarp and tip cap. The endosperm of kernel is the food storage and mainly is the carbohydrates. Embryo is a tissue form that will undergo fertilization and the new plant emerges from it (Panda, 2010). The endosperms contains approximately 80% of carbohydrates, 20% of the fat and 25% of the minerals, while for the embryo contains about 80% of fat, 75% of the minerals and 20% of the protein found in the kernels. For the pericarp and tip cap, they cover the entire surface of the kernel. Around 300-1000 number of kernels will formed from the ovules and is also depend on the variety or cultivar or the factors in the development stage.

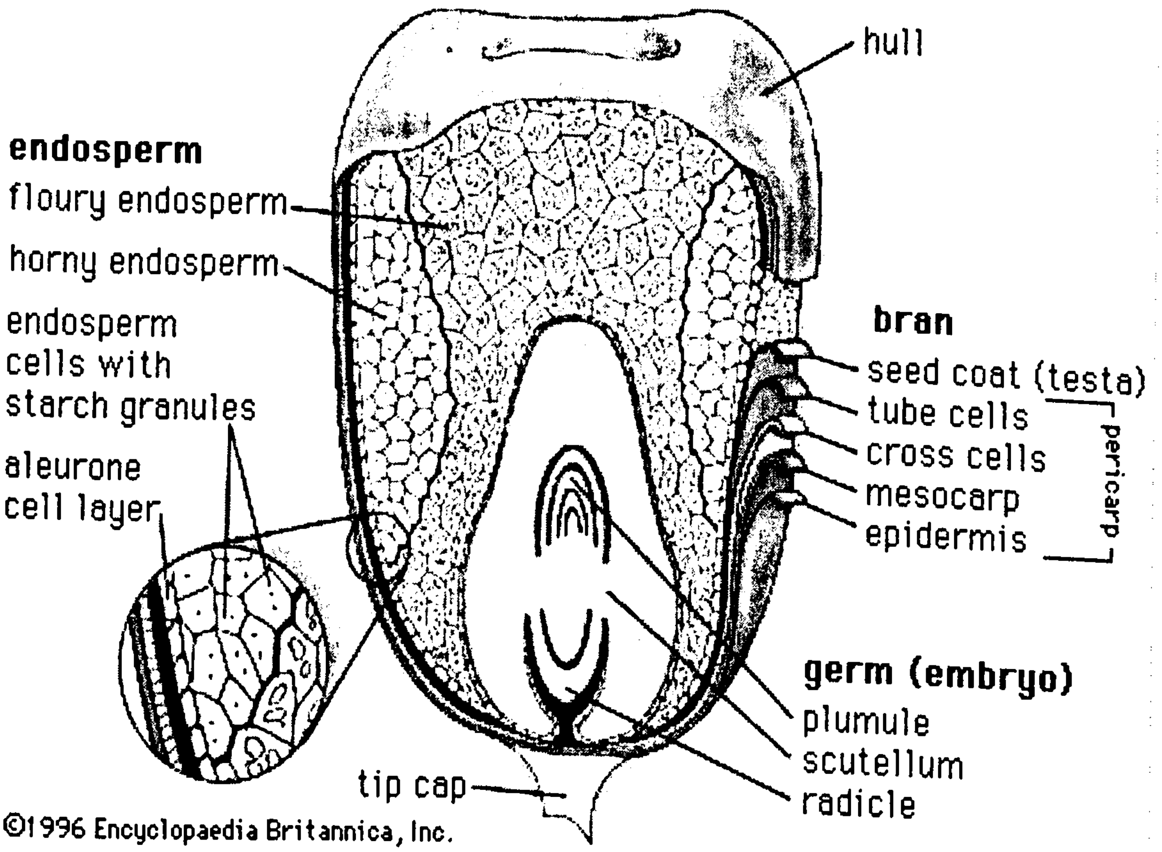

Figure 2.2: Layers and structure of the maize kernel

Source: Rashid *et al,* 2013

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