UNIVERSITY OF THE PHILIPPINES LOS BAÑOS

Master of Science in Agronomy

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GROWTH AND PRODUCTIVITY OF MAIZE (*Zea mays* L.) CULTIVARS AS AFFECTED BY DIFFERENT PLANTING DATES UNDER LOS BAÑOS CONDITION

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SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
UNIVERSITY OF THE PHILIPPINES LOS BAÑOS
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE
DEGREE OF

MASTER OF SCIENCE
(Agronomy)

December 2016 The thesis attached hereto, entitled **"GROWTH AND PRODUCTIVITY OF MAIZE (*Zea mays* L.) CULTIVARS AS AFFECTED BY DIFFERENT PLANTING DATES UNDER LOS BAÑOS CONDITION",** prepared and submitted by **KHIN HNIN YU** in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRONOMY)** is hereby accepted.

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BIOGRAPHICAL SKETCH

The author was born on April 27, 1980 in Myingyan Township, Mandalay Region, Myanmar. She is the 3rd child of Mr. Ohn Han and Ms. Ngwe Hla.

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KHIN HNIN YU

ACKNOWLEDGEMENT

The author is indebted to all of her teachers from primary school education to her Bachelor degree in Agronomy at Crop Production Cluster for their efforts and encouragement to pursue her degree.

First and foremost, the author is deeply indebted to **Dr. Pompe C. Sta Cruz,** her **A**dvisor and Chairperson on Advisory Committee, for providing her with his excellent professional guidance, advice, scientific discussions, encouragement, and patience in reviewing her thesis outline and thesis manuscript, and especially for his kink understanding to complete this work. The author also would like to express appreciation to **Professor Bong M. Salazar**, **Dr Ronaldo B. Saludes,** members of her advisory committee, for their kindness, guidance, comments and invaluable suggestions generously offered in improving this work.

The author expresses her gratitude to the **International Development and Research Center (IDRC,** Canada**)** for financial support and granted her the scholarship. The author wishes to express her gratitude and sincere appreciation to Southeast Asia for Education Organization Regional for Graduated Study and Research in Agriculture (**SEARCA**) for the support and set environment since the beginning till the end of the scholarship process. This study would have been impossible without financial support from (IDRC, SEARCA).

The author would like to acknowledge the Ministry of Agriculture, Livestock and Irrigation, Myanmar for giving permission to pursue her Master Program in the Philippines.

The author is sincerely grateful to the Dean and staff of the UPLB graduate school.

The author also extends her sincere appreciation to Mr Gregorio M. Villegas at the Crop Production Division, CSC, for giving his suggestions, guidance and proving field equipment.

The author wishes to express special gratitude to Kuya Benoy, Kuya Mando, and Ms Marilyn Yere for their kind support and friendship. Thanks are also extended to all the Agronomy staff of Crop Science Cluster, UPLB and all members of Myanmar Student Association (MSA) for their support help, friendships and environment set up.

The author's deepest appreciation goes to her parents, Mr. Ohn Han and Mrs. Ngwe Hla, and her brothers and sisters for their encouragement, and motivation.

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ABSTRACT

KHIN HNIN YU, University of the Philippines Los Baños, December 2016. "Growth and Productivity of Maize Cultivars as Affected by Different Planting Dates Under Los Baños Condition"

Major Professor: Dr Pompe C. Sta Cruz

The study evaluated four maize (*Zea mays*) cultivars (Supersweet, IES Glutinous-4, MMSU and Sweet Jubilee-209) that were established in four planting dates (9th Feb, 9th Mar, 9th Apr, and 9th May) under Loas Banos condition. The effect of varying growing environments imposed through different planting dates on maize cultivars were evaluated in terms of growth, yield components and yield. Planting date had significant effect on phenological durations of the maize cultivars. The February planting with high cumulative solar radiation had longest growth period. The April planting shortened the phenological stages of the maize cultivars. The February planted maize crops due to high solar radiation had the highest grain yield (3928.21kg ha^{-1}) with more leaves, taller stature, high leaf area index that contributed to high crop growth rates and high dry matter accumulation. The April planting with low solar radiation with high rainfall on the other hand, produced the lowest grain yield (2159 kg ha^{-1}) with least number of leaves, shortest stature, low leaf area index that contributed to low crop growth rates and low total dry matter accumulation with low cumulative solar radiation and high rainfall. MMSU cultivar produced the highest yield in four planting dates in which February planting date was also the best for MMSU cultivar and had the highest average yield (4160.41 kg ha^{-}1). Within the February to May planting window, the February planting date is recommended for growing maize crop under Los Baños condition. The MMSU cultivar performs well under Los Baños condition, particularly in February planting.

Keywords; maize, planting daes, cultivars, yield, climate, solar radiation, rainfall.

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L) is the third most important cereal crop both for human and animal consumption and ethanol production (Milander, 2015) after wheat and rice in world production (FAO, 2002), and the major staple food in most developing countries (Carraretto, 2005). It is the most popular cereal crop in the world due to its high productivity per unit area, lower cost to cultivate, its ability to grow quickly being short duration crop (Akbar et al., 2008), and its high photosynthetic activity as a C4 crop pathway. Maize is one of the valuable crops that are placed in the most important crops group of the world due to its versatility, vast compatibility and high-food value (Stoocksbury et al., 1994). Maize, at present time, is produced on nearly 100 M ha in 125 developing countries, one of the three most widely-grown crops in 75 countries and it is approximately produced to be over 800 Mt yr^{-1} of production at the global scale (Anley et al., 2013).

Maize productivity is dependent on the environmental climate conditions, such as: temperature, moisture, solar radiation, daylength, and soil fertility. Although rainfall limitation can cause damage to maize production in infested area, maize is grown in regions that receive annual rainfall of greater than 500 cm (Shaw, 1988). When maize is grown in drier areas, yields considerably depend on temporal rainfall if the crop is not irrigated. Highest maize yields can only be obtained under optimum moisture content during the growing season.

The PIDS (2009) reported that under Philippines condition, a typical crop cycle of maize can be completed within from 90-120 days after planting (DAP), the boiler type (food) maize could be harvested in 65-75 DAP, and the baby corn (vegetable) could be marketed after 50 DAP.

Significance of the Study

Philippines is ranked the 13th most climate-vulnerable country over the world (Ranada, 2015), and annually experiences serious to extreme climate change conditions. Maize productivity in the Philippines has been affected by poor soil fertility, incidence of pests and diseases, and of abiotic stresses such as drought and water-logging due to El Niño and typhoons, respectively.

Environmental climate variations associated with different planting times (solar radiation, rainfall) have a significant effect on the growth and development of maize plants. Each cultivar has an optimum plating time, and the greater the deviation from this optimum (early or late planting),the higher the yield loss (Sárvári and Futó, 2000). Many authors reported the planting time as an important factor that significantly affects the growth and yield of maize. According to Nielson et al. (2002), at present time, the challenge for maize growers is finding the thin window between the too early and too late planting.

The maize yield (*Zea mays* L.) consists of different proportional contributions of the effective factor in all growth stages from emergence to maturity. For a better understanding of climatic and cultural effects on maize yield and grain quality, intensive research that evaluates different geographic locations, planting times and cultivar selection are urgently required. In order to minimize negative effect of some abiotic and biotic stress on maize plant, planting time can play a major role in determining the seed yield, quality, seed germination and understanding whole phenological stages in many regions. Norwood (2001) suggested that farmers should plant on more than one planting time in order to safeguard against unpredicted seasons. The optimum planting dates provide different growth conditions, such as: temperature, precipitation and solar radiation levels throughout the crop cycle (Tsimba, 2011).

Generally, yield reduction in most dryland regions occur because seasonal rainfall distribution is erratic (Du Toit et al., 2002). As Philippines is a tropical dryland country, in a successful maize production requires an understanding of various management practices as well as environmental climate conditions that affect crop performance (Eckert, 1995). Selection of appropriate cultivars and planting times are cultural practices that have been shown to affect maize yield potential and stability (Norwood, 2001). Cultivar selection, for a particular region, and planting times are other factors that consistently affect maize yield.

Determining the optimum planting dates for maize through field experimentation requires trials that are repeated for many years to catch rainfall variability, solar radiation, and temperature. Choosing planting date plays an important role in agronomic strategies for increasing or maintaining the crop yield under unfavorable environmental conditions during critical crop phenological stages. Adaptability of varieties to varying climates in different growing environments may differ. The experimental data for one area may not be relevant for another because of differences in rainfall distribution and soil type. The optimum plating date is considered to be the date where yield and profit are maximized by reducing the production risks to minimum, while at the same time allowing the crop to fit within the overall farming system (Tsimba, 2011). Accordingly, variety selection trials at different planting time are necessary to identify the best suitable varieties for given areas. Due to variations in climate and seasonal length, optimum maize planting dates differ across locations and seasons. Therefore, improving our understanding of the interactive effects between crop management practices and weather conditions is deemed necessary to enhance maize yield, improve the use efficiency of natural resources, and reduce the potential for environmental pollution.

Methodological Framework of the Study

The methodological framework of the study is shown in Figure 1. The growth, development and yield response of maize vary with the function of weather condition, crop management practices, and soil characteristics. The crop management practices, such as optimum planting date and cultivar which interact with the crop environment, may affect the agronomic and physiological responses of the crop, which in turn will influence its growth rate, dry matter partitioning, and development of yield components. Leaf area index (LAI), crop growth rate (CGR), harvest index (HI), and grain yield of maize will be used as major parameters in the evaluation. The result of this study will provide information on the productivity of four maize cultivars as affected planting dates.

Eventually, the optimum planting date for particular maize cultivar will be determined under Los Baños climatic condition.

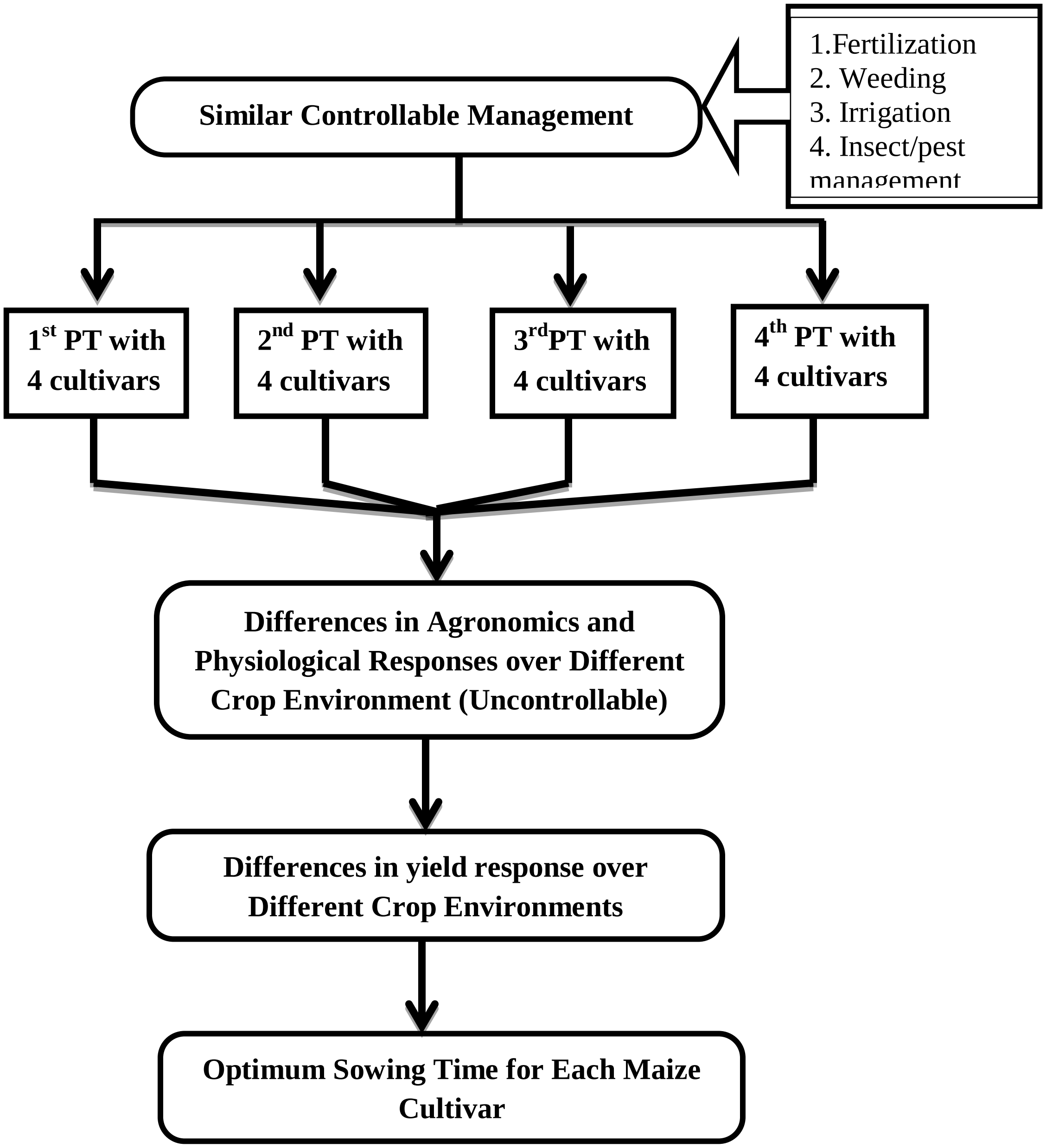


Figure 1. Methodological framework of the study.

PT= Planting time

Objectives of the Study

This study evaluated four selected maize cultivars that were established at different monthly planting dates (February to May 2016) under Los Baños climate condition. Appropriate planting time monthly February to May of maize cultivars under Los Baños climate condition was determined. Specifically, the study:

1. Evaluated the growth and agronomic responses of four maize cultivars at different crop growth stages due to planting times;
2. Assessed the effect of planting time on the development of yield components of four cultivars;
3. Determined the productivity and adaptability of four maize cultivars planted from February to May under Los Baños condition.

CHAPTER II

REVIEW OF LITERATURE

Developmental Stages of Maize Crop

The growth of maize can be divided into vegetative and reproductive stages. Vegetative stage is defined as the development between seedling emergence and tasseling (VT) stage, by the number of leaves with visible collars, and reproductive growth stage, the development between silking and grain maturity stage. At the VT stage, the tassel emerges from the flag leaf and maize plant has the maximum leaf area, all the numbers of leaves and ear shoot have been produced during this period. When the silks emerge from the ear shoot, the plant is considered to be in the silking stage which is the first phase of the reproductive stage. Westgate et al. (1997) documented that silking stage is the most sensitive period to stress due to the fact that the number of kernels perear is determined in this stage. Later reproductive stage, include: R2 (blister) stage in which starch is just beginning to accumulate, and silks begin to dry and darken; R3 (milk) stage; R4 (dough) stage; R5 (dent); and R6 (physiological maturity) stage. All of these stages are determined based on the appearance and physical properties of the kernels. Maize grain yield can be described as a function of the rate and duration of dry matter accumulation by the individual kernels multiplied by the number of kernels per plant (Westgate et al., 1997). In simple terms, maize grain yield is a product of the number of ears produced and the average weight of the grain on the ears. Thus, anything that affects one or both of these factors will significantly affect the final yield (Hatfield et al., 1984). According to Hashemi et al. (2005), grain yield per unit area is the product of grain yield per plant and number of plants per unit area.

Optimum Input for Maize Production

Maize demands less production inputs especially water, and it develops well in marginal areas, making it a feasible source of livelihood for resource-restrained smallholder farmers (PIDS, 2009). The most desirable soil for corn production is deep, medium textured soil that is easy to drain water and possesses high organic matter and water holding capacity (PCARRD, 1981). Maize has high productivity due to its large leaf area and being a C4 plant has one of the highest photosynthetic rates of all food crops. It has the highest potential for carbohydrate production per unit area per day. It can be grown throughout the year because of its photo-insensitiveness. The maize seed contains 11% protein and its nutrient value is higher in comparison to rice and wheat (Chowdhury and Hassan, 2013).

Crop yield depends on many factors such as crop management practices, soil fertility and crop environment weather conditions because the variability in the crop production is the function of the temporally-variable climate factors. Among these factors, crop management practices, such as sowing time, weeding, fertilization, irrigation, variety choice, insect/pest management can be controlled. On the other hand, environmental climate factors, such as temperature, rainfall, solar radiation, wind and humidity, cannot be controlled. In order to get the maximum yield of corn by sowing at the optimum time with the suitable choice of variety, knowledge from the literature for optimum input for maize is of primary importance.

According to Hanway (1966) and Shaw (1977), 41-64 cm of water is required to produce an acceptable maize yield but others have documented that normal yields can be obtained with as little as 30 cm of water (Lamm et al., 1995; Robins and Rhodes, 1958). Although maize is grown in areas that receive annual rainfall of more than 500 cm, extreme rainfall can damage maize crop, especially with water-logging problem (Shaw, 1988). Follett et al. (1978) observed that if maize is grown in arid areas, yields are greatly variable depending on temporal precipitation without irrigation. However, Devi and Rao (2002) reported that the water requirement for maize production can be determined based on the variability of evapotranspiration.

Maize Productivity and Varying Growing Environments

Yield potential is defined by Evans (1993) as the yield obtained when a crop is grown under field conditions with management practices that seek to excrete growth reductions from deficiencies of nutrient, insect pests, diseases, weeds, and moisture deficits or water-logging throughout crop growth period from planting to maturity. Most of these management factors can be controlled by the growers, but the environmental climate factors cannot be manipulated by the growers. It was reflected by Tsimba (2011) that if nutrients are non-limiting in maize cultivation, its growth and development in the field are primarily determined by temperature, solar radiation, photoperiod and water availability (rainfall) which vary in time and space. Hence, crops planted on different dates experience dissimilar environmental conditions.

Among the environmental factors, solar radiation interception during the crop growth plays an important role for final yield. It was explained by Muchow and Carberry (1989) that radiation interception strongly depends on growth duration which is determined by crop phenology, and leaf canopy development which is influenced by ambient temperature. Leaf canopy development determines the LAI of the crop, thereby dictating the proportion of incident radiation that is intercepted. Similarly, temperature primarily influences on growth duration, with lower temperature increasing the time that the crop can intercept radiation (Muschow, 2000).In crop production, the utilization of solar radiation is the most important one which is influenced by canopy architecture (Daughtry et al., 1983).

Maize plants in a field are always influenced by competition with other plants for solar radiation, nutrients, and water (Rajcan and Swanton, 2001). There is a strong relationship between photosynthetic efficiency and growth of maize, and the effect of canopy architecture on vertical distribution of light within the canopy. On the other point of view, biomass accumulation is directly proportional to the amount of radiation intercepted and for a given HI, while grain yield is directly related to the biomass accumulation. Consequently, high maize yield is associated with low temperature and high solar radiation within the range of environments. Solar radiation and temperature regimes set a finite limit to potential yield in a given environment. Accordingly, the crop productivity varies with the environment that experience during crop growth period. Environmental changes associated with different sowing dates (sunshine, temperature) have a modifying effect on the growth and development of maize plants. Each cultivar has an optimum sowing date, and the greater the deviation from this optimum (early or late sowing), the greater the yield loss (Sárvári and Futó, 2000).

The most important goal in any farming system is to minimize risk, maximize productivity and make profit. In general, the low productivity of dryland maize could be attributed to a combination of factors including low soil fertility, drought, low temperatures, erratic rainfall and deficient soil moisture during the growing season (Major et al., 1991). Of all these factors, erratic rainfall and drought are perhaps the more difficult phenomena to manage, primarily because their occurrences are unpredictable (Du Toit et al., 2002). They are more detrimental during the flowering, grain formation and filling stages of maize, which result in severe yield losses (ARCGCI, 2002).

Varying Planting Time and Maize Productivity

Appropriate planting date for a maize cultivar has the greatest influence on development of maize, as it determines the rate and duration of developmental phases which is influenced by environmental factors. The optimum sowing date generally varies depending on the climatic condition of the region and the cultivar to be grown. Failure to achieve the optimum timing for planting is one of the main contributors to minimum yields (Johnson and Mulvaney, 1980). Tismba (2011) described that due to variations in climate and season length, optimum planting date differs across regions, and seasonally within a region. Planting date is one of the most important components of a maize cropping system that can influence grain yield and yield components significantly (Ahmadi et al., 1993). Bollero et al. (1996) mentioned that the yield differences between planting dates could be related to leaf area development. They found grain yield to decrease linearly with decreasing soil temperature, which affected leaf area development. They concluded that increase in grain yield due to increasing soil temperature is attributed to the development of a larger leaf area index. Otegui and Melon (1997) reported that delayed planting is generally accompanied by increased temperatures under the temperate region which accelerated crop development and decreased the accumulated solar radiation, resulting in less biomass production, kernel set, and grain yield.

Among the cultural practices for maize production, sowing maize cultivar at the optimum time has the largest influence on development of maize as it determines the rate and duration of developmental phases. Then, maize cultivation markedly depends on the right choice of varieties so that the length of growing period of the crop matches the length of the growing season and the purpose for which the crop is to be grown. The optimum planting date generally varies depending on the climatic condition, especially those that affect the yield- determining parameters in maize. Solar radiation, temperature, rainfall, and variety to be grown are identified to be the key factors in the maize by environment interaction. For this condition, (Villalobos et al., 2002) reported that in the interception of light (LI) by a canopy, the difference between the incident and reflected solar radiation by the soil surface is a major factor that determines crop development and provides the energy needed for fundamental physiological processes, such as photosynthesis and transpiration. Moreover, the amount of availability of solar radiation depends on the planting time.

Significant interaction between cultivar yield and planting date indicated that the optimum planting time is an important factor in corn production, taking into consideration the various environmental stresses (pests, climate and soil) that could hamper production (Valerio et al., 2014). Planting date and variety selection, including soil fertility, temperature regimes and irrigation are the fundamental factors influencing maize production (Ramankutty et al., 2002). For optimization of yield, planting at the appropriate time is very critical, as delay in planting date may lead to a linear decrease in grain yields (Anapalli et al., 2005). The recommended crop management adaptations to mitigate the climate change effects include the planting date adjustment, and the combination management of planting date and cultivar adjustment (FAO, 2014). For optimum production, seed must be planted at the proper time since considerable yield reduction can occur if the crop is planted too early or too late (Chaudry, 1994). According to Khan et al. (2002), many factors are responsible for low yield of maize, and one of the most important factors contributing to yield reduction is the planting of maize either too early or too late. The authors concluded that a delay in planting date decreased grain yield by 58.2%, and also resulted in lower grain mass and number of grain per ear. Otequi et al. (1995) found that early and intermediate under the temperate condition in France tended to allow plants to best utilize solar radiation, thus resulting in higher grain yield, provided that growth factors such as water and nutrient supply were optimal.

Of all the management aspects of growing a maize crop (cultivar selection, plant density, amount and timing of fertilizers, etc.), planting time is probably the most subject to variation because of the very great differences in weather at planting time between seasons and within the range of climates (Otegui et al., 1995). The year-to year variation in plant establishment, pest and disease incidence makes it difficult to predict optimum planting dates for maize crops (Oktem, 2000). In practice, recommended dates are normally drawn up from the results of long-running series of agronomic experiments, which can identify mean planting dates for highest yield together with realistic estimates of expected yield penalties for each week of delay in planting (Lauer et al., 1999).

Some researchers claim that sowing date is very important in maize (Kucharik, 2008 and Wiatrak, 2004). Saseendran et al. (2001) concluded that suitable sowing date produces higher maize yield, and Dwyer et al. (1991) claimed that in each area, the determination of appropriate planting date is very important in order to obtain highest maize yield. At present, introduction of short duration varieties in weather with marginal increases in minimum temperatures over the years have meant that maize is now grown in either cooler short season or areas that were previously regarded as unsuitable for maize production in other regions, such as in New Zealand.

Maize Cultivar Productivity

The most desirable genotype is the one which shows wide-adaptability to the varying crop environments. Grafius (1960) documented that in a given climate condition, the potential grain yield components of maize is influenced by the grain yield of a particular maize variety (inbred or hybrid). Gardner et al. (1985) concluded that the grain yield of maize is the product of three yield components, i. e. the number of ears per unit area, the number of grains per ear and the unit grain weight. Ragheb and Rassy (1989) reported that hybrids generally exhibit the significant differences in grain yield due to genetic factors and the different physiological factors, which affect the grain yield. The extended root system with more root hairs to absorb more nutrients and the canopy architecture to intercept more photosynthetic active radiation (PAR) are some of the identified physiological responses. Wajid et al (2007) reported there were significant differences in ears per plant of various hybrids (B-202, M-919 and P-31-R-88). Grzesiak (2001) reported that there is a significant genotypic variability among different maize genotypes for various traits. Ihsan et al. (2005) also reported significant genetic variation for morphological traits for maize genotypes and, Welsh (1981), claimed that such variability is an important key to crop improvement. Major and Dynard (1972) reported that LAI of 2.6 is optimum for grain yield in hybrids, while 2.0 is considered optimum for inbreds. At optimum LAI, about 90% of the incoming solar radiation is intercepted by the crop canopy. Sabir et al. (2000) reported significant differences were observed among the hybrids in terms of HI. Devi et al. (2001) reported that the grain yield is directly influenced by the number of ears per plant, ear length, number of seeds per ear and 100-seed weight, while several other parameters are indirectly affected. Any kind of stress, for example a drought stress, during or around the stage(s) which occur these components may seriously affect grain yield. Thus, not only choosing optimum cultivar (genotype) but also avoiding being stressed at the critical development stages play an important role in attaining maximum yield. Therefore, any alteration either agronomic management or breeding type (genotype or cultivar) will affect the yield components and the final maize yield.

CHAPTER III

MATERIALS AND METHODS

Time and Place of Study

This study was conducted at the Central Experimental Station (CES) of the University of the Philippines, Los Baños (UPLB), College, Laguna (N 14°10′, E121° 15′, 74 masl) falling within both the dry and wet seasons of 2016 growing periods (February to August 2016). The study was started from February 2016 and the harvesting of fourth planting date was by August 2016. The maximum rainfall period in the experimental period is usually from June to December. Figure 2 shows the average monthly rainfall pattern in the experimental site for the period of 30 years (1986-2015).

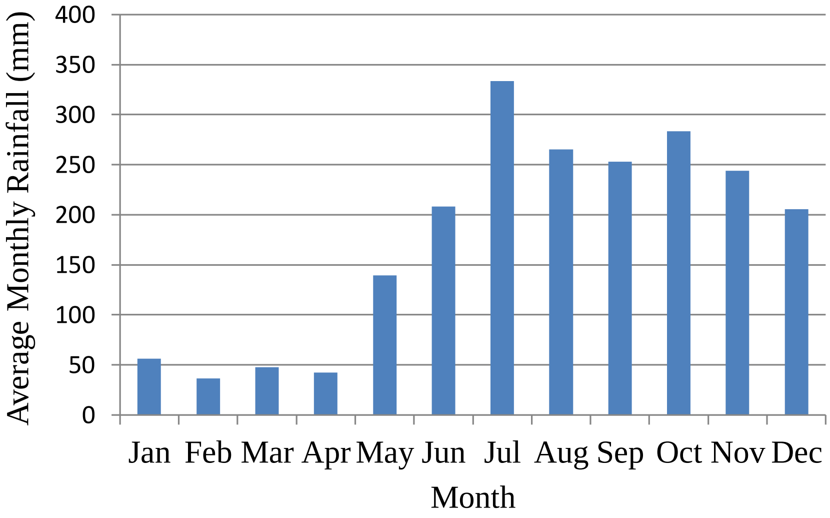


Figure 2 Average monthly rainfall for 30 years period (1986-2015) at UPLB, NAS.

Experimental Design and Treatments

Four Philippine maize cultivars (Supersweet, IES Glutinous - 4, Sweet Jubilee 209 and MMSU) were planted at different planting dates in this study. The experiment was laid out in RCBD with three replications for each of the planting date, namely: [9th February (P1), 9th March (P2), 9th April (P3), 9th May (P4)]. Treatment details are shown in Table 1, and experimental layout is shown in Appendix Figure1.

Table 1 Treatments imposed in the study.

PLANTIG TIME	MAIZE CULTIVAR
February Plantign 9th Feb 2016	IES Glutinous-4 Sweet Jubilee-209 MMSU Supersweet
March Planting 9th Mar 2016	IES Glutinous-4 Sweet Jubilee-209 MMSU Supersweet
April Planting 9th Apr 2016	IES Glutinous-4 Sweet Jubilee-209 MMSU Supersweet
May Planting 9th May 2016	IES Glutinous-4 Sweet Jubilee-209 MMSU Supersweet

IES Glutinous-4 (open-pollinated variety), which is recommended for nationwide planting, is an early-maturity group and matures in 98-103 DAP. This cultivar was obtained from Cagayan Valley Research Center (CVRC), Ilagan. It has the ability to yield an average of 5800 kg ha^{-1}. Its highest yield (9330 kg ha^{-1}) for this cultivar was obtained in Sta. Maria, Pangasinan. Supersweet cultivar (open pollinated yellow corn) was obtained from Institute of Plant Breeding (IPB), UPLB and the recommended population is 26,000-27,000 plants ha^{-1} if irrigated or 20,000-24,000 plants ha^{-1} if not irrigated, and planted at 76 cm between rows and 15-20 cm between plants. When Supersweet is grown as table consumption and it can be harvested in 72-76 DAP. The MMSU (open pollinated white maize) cultivar was obtained from Mariano Marcos State University (MMSU) in Batac, Ilocos and it matures in 94-99 DAP. This variety can produce the yield of 5720 kg ha^{-1} under good agricultural management practices with recommended complete inputs. Sweet Jubilee-209, a hybrid, matures 90-105 DAP. It is one of the latest maturing varieties and it may not mature in some cooler climates.

Crop Establishment and Maintenance

The experimental area was plowed two times and harrowed once before planting. The gross experimental plot size was 35 m long from North to South and 47.5 m wide from East to West. Area of each plot had a dimension of 4.5 m x 5 m, having seven rows of 4.5 m length in which 18 plants per row were sown. Plants were spaced at 0.75 m between rows and 0.25 m between plants, with plant population of 53,333 plants ha^{-1}.

Three seeds of maize per hill were planted by hand with the spacing of 0.75 m between rows and 0.25 m between plants at a seeding depth of 2-4 cm. Gap filling was done immediately after 90% of the plants had emerged. After complete emergence (third leaf stage) or about 10 (DAP), only one plant per hill was maintained by thinning out excess seedlings.

Crop Management

To supply 40 kg ha^{-1}for each nutrient of NPK, 643.5 g complete fertilizer (14-14-14) was applied for each experimental unit as basal fertilizer before planting. The basal fertilizer was placed at approximately 7 cm below the soil surface and covered and compacted with a soil layer, above which three seeds were placed to make a seeding depth of 2-4 cm by hand seeding. To apply the remaining 80 kg N ha $^{-1}$, second round fertilizer application in the form of urea was done at 25 (DAP) for all planting dates. After planting, sprinkler irrigation was immediately done. Furrow system of irrigation was also practiced at seven days interval depending on the crop water requirement and soil moisture content. Insect/pest and disease control management was carried out as necessary. For the super sweet and sweet jubilee cultivars, corn borer protection was usually done during silking stage. Hand weeding was carried out during the vegetative growth stages. Weeding was made at the second round application of fertilizer.

Data Gathered

Soil Data

Composite soil samples were taken from five randomly-selected soil samples that represent the whole experimental field using soil auger at 5 DAP. Soil sampling was done up to a depth of 20 cm to get four soil layers: 0-5 cm, 5-10 cm, 10-15 cm and 15-20 cm.

Soil samples were processed and submitted to Soil Analytical Laboratory, Agricultural Systems Cluster (ASC), at UPLB to determine the required soil physical (soil texture, water holding capacity, bulk density and particle density) and chemical characteristics (soil pH, organic matter content, available phosphorous, exchangeable potassium, total nitrogen and cation exchangeable capacity).

Meteorological Data

Daily weather information data, such as: minimum and maximum air temperatures, relative humidity, solar radiation, and precipitation were obtained from the National Agrometeorological Station of the University of UPLB. Daily solar radiation was obtained from the Climate Unit, Crop and Environmental Sciences Division of the International Rice Research Institute (IRRI). Cumulative solar radiation was calculated for each experimental unit by summing up the daily solar radiation during radiation for vegetative growth stage and reproductive stage.

Agronomic Parameters

The data collection through experimentation was conducted in 15-day interval until harvest and particularly during V6 (sixth leaf emergence stage), R1 (50% silking stage), R4 (50% dough stage), and R6 (50%physiological maturity) stages. The following agronomic parameters, physiological parameters, and yield component parameters were collected:

Plant height (cm). Ten plants were randomly selected and tagged at about 10 DAP. Plant height was measured from the tagged plants by using the measuring tape from ground level to the highest leaf tips at 15-day interval from 15 DAP to tasseling.

Total number of leaves. The total number of leaves was counted at tasseling. To get the accuracy observation on total leaf number, a fifth leaf of 10 plants per plot per replication was marked with permanent marker paint before the cotyledons fall off.

Physiological Parameters

Phenological dates. Detailed observations on phenology and crop growth measurements were carried out from using 10 monitoring plants, which were randomly tagged from the center of each plot. Recording the length of time in terms of number of days for attaining a particular physiological event were done based on Mourice et al. (2014) specifically: 1) the time taken for crop emergence, 2) days to 50% tasseling and 3) 50 % start of flowering (silk stage or R1 stage), 4) days to 50 % dough stage (R4 stage), and 5) days to 50 % physiological maturity (R6 stage) (Chisanga et., al, 2015). Days to 50% tasseling was recorded when tassels were observed in 50 % of the tagged plants in each plot. Days to 50% silking stage (R1) and dough stage (R4) were recorded similarly as at VT stage. For the observation of physiological maturity, grains were removed from the base, middle and distal end of each marked ear using two plants sampled from the border row in each plot, at an interval of 2-3 days as soon as browning of the husks has started. Days to physiological maturity was recorded when 80% of the grains in each ear formed a black layer, an indication that there is no further accumulation of assimilates in the plant.

Leaf area (LA) and leaf area index (LAI). For leaf area measurement, three randomly-selected sample plants were observed at 15-day interval. Leaf area was obtained by multiplying the leaf length (L) which was measured from leaf tip to the point of the collar, with leaf width (W) which was measured at the widest point of the leaf, and multiplied by a coefficient factor of 0.75 (Mokhtarpour et al., 2010). Leaf area was calculated using the formula: $LA = L * W * 0.75$

The LAI calculation was made depending on the plant density (Lukeba et al., 2013), i.e. LAI = leaf area (m^2 $plant^{-1}$) × number of plants m^{-2}. The LAI is the total functional leaf area per unit ground area. The LAI was calculated from three plants at 15-day interval (biweekly).

Plant biomass and crop growth rate (CGR). To determine plant biomass, sampling of three plants was done during at 15 days interval and at specific growth stages, such as: 50% visible collar of 6th leaf (V6), 50% silk visible outside husks (R1), 50% “dough” stage (R4), 50% physiological maturity (R6), and harvest time. To obtain biomass, three randomly-selected plants were pulled out from the ground from each plot. Leaves were separated from the stem, chopped and dried in the shade for 3 days. Stems, roots, ears, tassels, husks, and leaves were separately oven-dried at 78˚C for 36-48 h. Plant biomass was obtained by weighing the oven-dried plant samples. The CGR estimates the increases in biomass by integrating the gain from photosynthesis and loss from respiration, was computed, using the formula:

$$\mathrm{CGR} = \frac{(\mathrm{W2}-\mathrm{W1})}{\mathrm{GA}(\mathrm{t2}-\mathrm{t1})}$$

where: W_1 is plant dry weight (g) at time 1; and W_2 is plant dry weight (g) at time 2; and GA is the ground area expressed in m^2. In this study, CGR at V6 was calculated as follow:

$$\mathrm{CGR\ (V6)} = \frac{(\mathrm{W2}-\mathrm{W1})}{\mathrm{GA}(\mathrm{t2}-\mathrm{t1})}$$

Where: w_2 was the plant dry weight at V_6 stage, w_1 was the number of seeds per m^2 (seed weight), t_2 was the time to reach V_6 stage, and t_1 was the time at emergence.

Yield and Yield Components

The designated harvest area was 2 m^2 in each plot for all treatments. All plants within this area were harvested to determine the ear number (ears m^{-2}) and plant population (plants m^{-2}). A subsample of three plants from the harvest area was selected for yield and yield component data calculations. In order to get the average measurement, plant parts were separated into leaves, stover, cobs, husks, grains, ears, and roots. All plant parts were oven-dried at 78˚C, for 36-48 h, and plant biomass was obtained by weighing the samples. Specifically, the following parameters were gathered:

Number of ears per m^2 (ears). This parameter was measured from 2 m^2 sample harvest area by counting the number of ears. Average numbers of ears per m^2 was calculated.

Kernel weight per m^2. All the grains were removed from the three randomly selected sample plants and separated from the cobs. After drying the sample grains to 14% moisture content, all of the grains were weighed. Then, the average grain weight per plant was calculated by dividing the total grain weight from the three sample plants by the total number of plants. The kernel weight per m^2 was calculated by multiplying the average grain weight per plant with number of ears per m^2.

Thousand kernel weight (g). For each experimental unit, 1000 kernels from 2 m^2 sample harvest area was counted, dried to 14% moisture content and weighed.

Harvest index (HI). The HI was obtained from three randomly selected sample plants from each plot at harvest time. Total shoot dry mass was all the plant parts except the economic harvest portion (grais) and HI was computed by using the formula:

$$\mathrm{HI} = \frac{\text{Dry mass of harvest component (g)}}{\text{Total shoot dry mass (g)}}$$

Grain yield (14% MC, kg ha^{-1}). Grain yield was calculated from the designated 2 m^2 harvest area, calculated the average grain yield for 1 m^2 harvest area, and adjusted to 14% moisture content by using the formula:

$$\mathrm{GY} = \mathrm{HGY}\ (\mathrm{gm}^{-2}) \times \frac{1}{1000} \times \frac{10000}{1\ \mathrm{ha}} \times \left[\frac{100 - \mathrm{MC}}{86}\right]$$

Where, GY is grain yield (kg ha^{-1} at 14 % moisture content), HGY is harvest grain yield (g m^{-2}) and MC is moisture content.

Statistical Analysis

The data gathered from the experiment were analyzed by using Statistical Tool for Agricultural Research (STAR) version 2.0.1 (IRRI-STAR). The treatment means were compared by using Least Significant Difference (LSD) Test. Correlation analysis was done on selected parameter.

CHAPTER IV

RESULTS AND DISCUSSION

Meteorological Characteristics of the Experiment

The physical and chemical properties of the soil in the experimental site are presented in Table 2. The soil predominantly contains highly weathered clays with relatively low pH level, available potassium (K), nitrogen (N), and with high water-holding capacity which is the cause of the observed water-logging problem in the study site. Special management including drainage during heavy rainfall or irrigation during dry spell was important due to high clay content of the experimental field.

Table 3 shows climatic characteristics within the growth duration of crops as affected by the planting time. Considerable differences in the total amount of cumulative solar radiation (CSR) and rainfall that occurred within each planting time provided diverse growing environments for the evaluation of the performance of four maize cultivars. Highest CSR (1791.4 MJ m^{-2}) was obtained in the February planted crops while lowest amount rainfall of 112.8 mm was received. The May planted crops on the other hand, received the lowest amount of CSR (1518.8 MJ m^{-2}) but had the highest amount of rainfall (489.5 mm) during the crop growth period (Figure 6). There were no significant differences in average daily maximum and minimum temperatures among the four planting months, except for RH that was highest (85.65 %) during the crop growth period in May planted crops (Figure 7).

Table 2 Physical and chemical properties of soils at the field experimental site, Los Banos, 2016.

SOIL PARAMETER	SOIL DEPTH (cm)			
	0-5	**5-10**	**10-15**	**15-30**
Mechanical analysis				
Sand (%)	17	15	18	20
Silt (%)	34	31	31	28
Clay (%)	49	54	51	52
Texture	Clay	Clay	Clay	Clay
OM (%)	1.82	1.66	1.65	1.74
WHC (%)	80	80	82	80
PD (g cm-3)	2.66	2.47	2.62	2.57
BD (g cm-3)	1.01	-	-	-
K (me 100g-1 soil)	0.6	0.54	0.6	0.6
CEC (%)	31.68	31.37	34.01	31.22
pH	6	6.2	6.3	6.3
Total nitrogen (%)	0.09	0.09	0.09	0.09
Available exchangeable phosphorous (ppm)	11	51	50	52

Table 3 Climatic characters during crop growth period of four maize cultivars as affected by planting time.

WEATHER PARAMETER	PLANTING TIME			
	February	**March**	**April**	**May**
Cumulative solar radiation* (MJ m-2)	1791.4	1771.6	1709.2	1518.8
Average Daily Solar Radiation* (MJm-2d-1)	17.4	17.7	16.9	15.3
Cumulative Rainfall* (mm)	112.8	122.0	293.4	489.5
Average Relative Humidity* (%)	79.9	79.6	81.1	82.7
Average Daily Minimum Temperature* (°C)	23.6	24.4	24.8	24.9
Average Daily Maximum Temperature* (°C)	33.1	34.1	34.0	33.3

* - for whole growth duration period in each planting time

The cumulative and mean daily solar radiation, cumulative rainfall, mean daily minimum and maximum temperatures, and daily RH that occurred during the experiment are presented in Table 4. Cumulative solar radiation and total monthly rainfall received by the crops planted in different months are also presented in Appendix Figure 2.

Appendix Figure 2 shows the information on the daily solar radiation, and daily rainfall that occurred within the growth period of crops planted within the months of February to May. Daily maximum temperature received during each planting time is presented in Appendix Figure (3).

Table 4 Cumulative and mean daily solar radiation, cumulative rainfall, mean daily minimum and maximum temperatures and mean daily relative humidity during the experiment (February- August 2016), Los Baños.

MONTH	**CLIMATIC PARAMETER**					
	Cumulative SR(MJ m^{-2})	**Mean Daily SR(MJm^{-2}d^{-1})**	**Cumulative Rainfall (mm)**	**T_{min} (°C)**	**T_{max} (°C)**	**RH (%)**
February	403.80	13.92	39.40	22.31	30.17	85.17
March	435.00	15.00	3.90	22.93	32.33	82.06
April	526.27	18.15	46.60	24.42	34.52	78.10
May	528.99	18.24	45.50	25.18	34.66	78.52
June	428.91	14.79	118.40	24.63	33.42	84.43
July	481.70	16.61	132.50	24.57	32.21	84.87
August	432.08	13.17	252.8	25.58	31.77	81.88

SR - Solar Radiation, T_{min}-Minimum Temperature, T_{max} - Maximum temperature
RH - Relative Humidity

Effect of Varying Planting Time on Phenology and Growth of Maize Cultivar

Crop Phenology

Days to 50% V6 (vegetative).The number of days to reach 50% V_6 was significantly ($P<0.05$) affected by both planting time and cultivar (Table 5 and Appendix Table 1). Sweet Jubilee-209 had the longest number of days to reach 50% V6 (23.9 d), followed by the Supersweet, MMSU, and IES Glutinous - 4 cultivars, which were not statistically different (22.4, 21.7 and 21.5 d, respectively) (Appendix Figure 4). The

February planting had the longest number of days to reach V6 stage (24 d), followed by the March and April plantings (22.8 and 22.1 d, respectively). The maize crops planted in May had the shortest number of days (20.3 d) to reach 50 % V6 (Appendix Figure 5).

***Days to 50% tasseling*.** The days to 50 % tasseling was significantly ($P<0.05$) differed by both planting time and cultivar (Table 5 and Appendix Table 1). IES Glutinous-4 and Supersweet, although not significantly different, had the longest days to reach 50% tasseling (52.2 and 50.2 d, respectively), followed by Sweet Jubilee-209 and MMSU, which were also statistically similar (49.6 and 44.2 d, respectively). Thus, MMSU was the earliest to tassel among the four cultivars (Appendix Figure 4).

The February, March and April plantings had similar (50.5, 49.5 and 50.5 d, respectively) days to tasseling, while the May planting had the shortest number of days (45.8 d) among the four planting times (Table 5, Appendix Table 2, and Appendix Figure 5). In this case, the May planting having the highest atmospheric moisture content (mean daily RH= 82.1 %) due to highest amount of rainfall, was the earliest to tassel. This observation could be due to high moisture content and high rainfall that may have reduced evapotranspiration.

Days to 50% silking. Days to silking had similar trend with days to tasseling. IES Glutinous-4, Sweet Jubilee-209 and Supersweet, although statistically similar, had the longest days to 50% silking (55.9, 54.9 and 59 d, respectively). Relatively, the cultivar Supersweet had the longest days to silking, while MMSU the shortest (48.7 d) (Table 5 and Appendix Figure 4).

The April planted crops had the longest days to silking (57.2 d), but did not differ statistically with the February, March and May planted crops (55.2, 54.4 and 51.7 d, respectively) (Appendix Figure 5). May planting had shortest, while the April planted crops had the longest days to silking. These results conform with the findings of Matzenauer et al. (1998), who found that early planted maize flowers earlier in the growing season in which atmospheric evaporative demand is usually low, minimizing the probability of moisture stress. Table 6 shows the interaction between cultivar and planting date for days to silking. The MMSU cultivar had the shortest days for silking stage, while Supersweet the longest.

Days to 50% physiological maturity. Analysis of variance is presented in Appendix Table 1. Table 5 shows that both the cultivar and the planting time had significant effect on the number of days to reach physiological maturity. Days to physiological maturity of IES Glutinous-4, Sweet Jubilee-209 and Supersweet did not differ (97.8, 95.8 and 99.2 d, respectively). Relatively, Supersweet had the longest for maturity, while MMSU had the shortest (87 d) (Table 5 and Appendix Figure 4).

Planting time significantly affected the number of days to 50 % physiological maturity in maize crops (Table 5 and Appendix Table 1). March and April planted crops reached physiological maturity earlier, (93.8 and 93.2 d, respectively), followed by the May planting (95.2 d) while February planted crops had the longest growing period (97.5 d) for maturity. The February planted crops were exposed to higher amount of solar radiation and relatively lower mean daily temperature especially at the vegetative growth stage (Appendix Figure 2), thus higher photosynthesis resulting to higher dry matter accumulation and yield due to longer growth duration. Tollenaar and Aguilera (1992) reported that late planting date, under Ontario condition, with low amount of daily incident radiation resulted to reduced cumulative intercepted PAR from silking to physiological maturity, thus shortened the growth period and reduced grain yield. Hardman and Gunsolus (2002), also observed that variations in planting affect the amount of intercepted solar radiation, which subsequently affected plant growth period and yield of maize. Khan et al., (2002) also observed that early maturity of late sown crop under Peshawar Khyber Pakhtunkhwa, Pakistan condition, is attributed to shortened vegetative and reproductive periods.

The interaction effect between cultivars and planting time was significant in terms of the number of days to reach 50 % physiological maturity in the evaluated maize cultivars (Tables 5 and 7, Appendix Table 1). Supersweet had the longest number of days to reach physiological maturity (101 d) when planted in February, followed by the March planting with (99 d) while April and May planted crops had the lowest (98.3 d). Supersweet and IES Glutinous-4 had both longest days to physiological maturity (100.7 d) in the February planting, followed March planting (97 d), and April and May plantings (96 d). MMSU cultivar when planted in February resulted to longest days to physiological maturity (92 d) among four planting times. For Sweet Jubilee-209, days to physiological maturity was the longest in the May planting (98.3 d), followed by April planting (97.7 d) and February planting (96.3 d). Thus, MMSU had the shortest growing period, while the Supersweet the longest. In terms of planting time, February planting lengthened the growing period of crops, followed by May planting. The relatively longer period of crop growth in February planted crops could have been due to relatively low mean daily temperature with high solar radiation which in turn increased source capacity, hence the best planting time for all of the maize cultivars evaluated.

Table 5 Days to 50% V6, 50% tasseling, 50% silking, 50% dough and 50% physiological maturity of maize cultivars as affected by planting time under Los Baños condition, 2016.

TREATMENT	CROP GROWTH STAGE (days)			
	50% V6	**50% Tasseling**	**50% Silking**	**50% Physiological Maturity**
Cultivars (C)				
IES Glutinous	21.25 b	50.25 a	55.92 a	97.75 ab
Jubilee	23.92 a	49.58 b	54.92 a	95.83 ab
MMSU	21.67 b	44.25 bc	48.75 b	87.00 c
Supersweet	22.42 b	52.17 a	59.00 a	99.17 a
Significance	**	**	**	**
Planting Time (PT)				
February planting	24.00 a	50.5 a	55.25 ab	97.5 a
March planting	22.83 ab	49.5 a	54.42 ab	93.75 ab
April planting	22.08 b	50.5 a	57.17 a	93.25 ab
May planting	20.33 c	45.75 b	51.75 ab	95.25 ab
Significance	**	**	**	**
Interaction				
C × PT	ns	ns	**	**
LSD0.05	1.3139	2.02	5.04	2.83
Mean	22.31	49.06	54.65	94.94
CV%	7.06	4.94	5.53	1.79

Means followed by the same alphabet do not differ significantly at 5% level.
ns - non significant, * - significant at 5% level, ** - highly significant at 1% level

Table 6 Interaction between cultivar and planting date for days to 50 % silking in maize cultivars planted in different months under Los Baños condition, 2016.

PLANTING TIME	**CULTIVAR**			
	IES Glutinous-4	**Sweet Jubilee-209**	**MMSU**	**Supersweet**
February	56.67 a	55.67 ab	52.67 a	56.00 b
March	56.00 a	51.33 b	48.00 ab	62.33 a
April	57.33 a	59.00 a	49.67 ab	62.67 a
May	53.67 a	53.67 b	44.67 b	55.00 b
LSD0.05		5.0398		

Means with the same letter within the same column are not significantly different.

Table 7 Interaction between cultivar and planting date on days to 50% physiological maturity (R_6) in maize cultivars planted in different months under Los Baños condition, 2016.

PLANTING TIME	**CULTIVAR**			
	IES Glutinous-4	**Sweet Jubilee-209**	**MMSU**	**Supersweet**
February	100.67 a	96.33 a	92 .00 a	101.00 a
March	97.33 b	91.00 b	87.67 b	99.00 a
April	96.33 b	97.67 a	80.67 c	98.33 a
May	96.67 b	98.33 a	87.67 b	98.33 a
LSD0.05		2.8315		

Means with the same letter are not significantly different.

As a summary, planting time significantly affected the number of days to V6, tasseling, silking and physiological maturity in maize cultivars planted within February to May 2016. The MMSU cultivar had the shortest duration for each of the growth stages. Supersweet cultivar on the other hand, had the longest duration for each growth stage. This implies that the number of days to reach each growth stage is genotype specific. The effect of planting time on the duration of phenological stages of same maize cultivar could be attributed to the differences in cumulative solar radiation and the amount of rainfall received by the crops planted at different months.

Growth Parameters

The analysis of variance table and mean values for number of leaves (NL), plant height (PH), leaf area index (LAI), total dry matter at final harvest (TDM) and harvest index (HI) were presented in Table (8) and Appendix Table (2).

Number of Leaves. Analysis of variance presented in Appendix Table (2) shows that the number of leaves significantly differed in cultivars planted at different planting months although no interaction effect between cultivar and planting time was obtained. The number of leaves due to cultivar and planting time treatments is presented in Table 8. Highest number of leaves was obtained in Supersweet (19.2), followed by IES Glutinous-4 and Sweet Jubilee-209 (18.5 and 18.1 respectively), while MMSU had the least number of leaves (16.9). This result shows that NL is cultivar specific. Moreover, cumulative rainfall at vegetative stage (CRFV) positively correlated with NL in IES glutinous - 4 and Sweet Jubilee – 209 cultivars ($r = 0.86^{**}$ and $r = 0.84^{**}$, respectively) (Table 9).

Among the planting time treatments, the April and May plantings produced the highest number of leaves (18.4 and 18.8 respectively), followed by February and March planting times (17.6 and 17.8 respectively) (Table 8). The number of leaves increased gradually from February to May plantings with a range of 17.6-18.8. Table 10 presents that CRFV and cumulative solar radiation at vegetative stage (CSRV) positively correlated with NL in maize crops planted in February ($r = 0.81^{**}$, $r = 0.83^{**}$, respectively). These results indicate that reduction of NL in the maize crops planted in February could be attributed by relatively higher amount of solar radiation and lower amount of rainfall in this planting time. In April planting, on the other hand, CRFV positively affected on NL ($r = 0.7^*$). This finding indicates that relatively higher number of leaves in this planting time was due to the relatively higher amount of rainfall. Thus, this study shows that the delay in planting time from February to May plantings resulted to higher number of leaves in maize cultivars. This could be due to higher amount of rainfall and RH that are more favorable to the production of leaves.

Plant height. Analysis of variance presented in Appendix Table 2 shows that plant height significantly varied due to planting time and cultivars, while no interaction effect was obtained. Among the cultivars, IES Glutinous-4 and Supersweet were the tallest (233.4 and 233.5 cm, respectively), followed by MMSU and Sweet Jubilee-209 (208.1 and 198.0 cm, respectively) (Table 8). Then, CSRV negatively correlated with PH in IES Glutinous–4, Jubilee and Supersweet cultivars ($r = -0.62^*$, $r = -0.78^*$, and $r = -0.59^*$, respectively) (Table 9). These results indicate that the plant stature is cultivar specific, and it is also affected by solar radiation at vegetative stage.

The February planted crops were taller (252.8 cm), followed by the May planted crops (225.8 cm) (Table 8). The February planting appears to be affected by relatively low mean daily minimum and maximum temperatures (Appendix Figure 4), relatively low RH, and higher amount of solar radiation during the crop growing period. Shorter plants observed in March and May plantings could be due to limited crop growing period,

i. e. translated to shorter growth duration, thus inadequate time for growth such as increment in height. These results are in agreement with the results of Jafari (2010) on forage millet, and with findings of Noormohamadi et al. (1997). These authors observed that the optimum temperature for maize growth and development is 18-32 °C. Temperatures of 35°C and above are considered inhibitory. Yokozawa and Hara (1995) observed that the final height of plant and the diameter of its stalk are strongly influenced by environmental conditions during stem elongation. Moreover, CSRV and CRFV positively correlated with PH of maize crops planted in February (Table 10). Thus, the February planting provided the most favorable growing environment for maize cultivars in terms of prevailing relatively low daily maximum temperature at vegetative stage and high solar radiation during critical growth stages.

Leaf area index. The increase or decrease in LAI has a direct effect on plant growth rate. This index is the main parameter for enhancing photosynthetic capacity and assimilate production in crops. Analysis of variance (Appendix Table 2) shows that LAI did not vary among cultivars but was affected by planting time, and no interaction effect between cultivar and planting time was obtained. Although LAI did not differ among cultivars, Supersweet had the highest LAI (2.3), followed by IES Glutinous-4 (2.1), Sweet Jubilee-209and MMSU with LAI values of 1.84 and 1.82, respectively (Table 8). The highest LAI of Supersweet and IES Glutinous-4 could be due to the significantly high number of leaves and taller plant statures in these cultivars.

The February planting produced the highest LAI (2.5), followed by the March and May plantings (2), while the lowest LAI of 1.50 was recorded in the April planting. Despite the relatively smaller number of leaves in February planting, highest LAI was obtained in this planting month considering the higher solar radiation during reproductive stage that enabled more leaf expansion, thus higher LAI. This result was earlier observed by Hesketh and Warrington (1989) who found that the planting season which received high amount of solar radiation has enhanced leaf development and higher LAI. Lizaso et al. (2003) claimed that average absorbed PAR by the leaf at reproductive stage is the determining factor for maize yield. Delay of sowing that shortens in the growing cycle caused reduction in LAI, a similar finding was reported by Noferesti (2006). This study found that LAI is more influenced by planting time rather than cultivars.

Table 8 Number of leaves (NL), plant height (PH), leaf area index (LAI), total dry matter at final harvest (TDM) and harvest index (HI) in maize cultivars as affected by planting time under Los Baños condition, 2016.

TREATMENT	**GROWTH PARAMETER**				
	NL (#)	**PH (cm)**	**LAI (cm^2cm^{-2})**	**TDM (kg ha^{-1})**	**HI (kg kg^{-1})**
Cultivars (C)					
IES Glutinous-4	18.52 b	233.38 a	2.06	11528.70 a	0.34 b
Sweet Jubilee-209	18.05 b	198.01 b	1.82	6243.23 c	0.27 c
MMSU	16.92 c	208.88 b	1.84	10337.97 a	0.40 a
Supersweet	19.16 a	233.53 a	2.29	8498.89 b	0.20 d
Significance	**	**	**ns**	**	**
Planting Time (PT)					
February	17.62 b	252.79 a	2.49 a	11126.89 a	0.35 a
March	17.80 b	197.38 c	2.01 b	8984.30 b	0.33 ab
April	18.39 a	197.79 c	1.50 c	6606.60 c	0.29 bc
May	18.84 a	225.83 b	2.00 b	9891.00 ab	0.25 c
Significance	**	**	**	**	**
Interaction					
C × PT	**ns**	**ns**	**ns**	**ns**	**ns**

Means followed by the same alphabet do not differ significantly at 5% level.
ns - non significant, * - significant at 5% level, ** - highly significant at 1% level

Table 9 Correlation coefficient (r) generated based on the effect of climatic parameter and cultivars on the growth parameters at varying planting times (February-May) under Los Baños condition, 2016.

CULTIVAR	CLIMATIC PARAMETER	PARAMETER			
		NL	PH	LAI	TDM
IES Glutinous-4	CSRV	-0.38^{ns}	-0.62^{*}	-0.59^{*}	-0.55^{ns}
	CRFV	0.86^{**}	0.11^{ns}	-0.25^{ns}	-0.13^{ns}
Sweet Jubilee-209	CSRV	-0.17^{ns}	-0.78^{**}	-0.54^{ns}	-0.53^{ns}
	CRFV	0.84^{**}	-0.13^{ns}	-0.42^{ns}	-0.57^{*}
MMSU	CSRV	-0.39^{ns}	-0.30^{ns}	-0.11^{ns}	-0.10^{ns}
	CRFV	0.29^{ns}	0.17^{ns}	-0.23^{ns}	-0.52^{ns}
Supersweet	CSRV	-0.38^{ns}	-0.59^{*}	-0.46^{ns}	-0.54^{ns}
	CRFV	0.42^{ns}	-0.18^{ns}	-0.29^{ns}	-0.32^{ns}

CSRV -Cumulative Solar Radiation at Vegetative Stage
CRFV - Cumulative Solar Radiation at Vegetative Stage
NL - Number of leaves, PH - Plant Height, LAI - Leaf Area Index
TDM - Total Dry Matter at the end of vegetative stage

Table 10 Correlation coefficient (r) generated based on the effect of climatic parameter and varying planting times (February-May) on the growth parameters of four maize cultivars under Los Baños condition, 2016.

PLANTING TIME	CLIMATIC PARAMETER	GROWTH PARAMETER			
		NL	PH	LAI	TDM
February	CSRV	0.81^{**}	0.60^{*}	0.26ns	0.14ns
	CRFV	0.83^{**}	0.57^{*}	0.28ns	0.13ns
March	CSRV	0.33ns	0.34ns	0.07ns	0.26ns
	CRFV	0.49ns	0.48ns	0.03ns	0.37ns
April	CSRV	0.58^{*}	-0.32ns	-0.23ns	-0.26ns
	CRFV	0.70^{*}	-0.11ns	-0.10ns	-0.20ns
May	CSRV	0.68^{*}	0.16ns	0.15ns	0.40ns
	CRFV	0.55ns	0.08ns	0.06ns	0.36ns

CSRV -Cumulative Solar Radiation at Vegetative Stage
CRFV - Cumulative Solar Radiation at Vegetative Stage
NL - Number of Leaves,PH - Plant Height, LAI - Leaf Area Index
TDM - Total Dry Matter at the end of Vegetative Stage

Crop growth rate. Crop growth rate is an index of canopy photosynthesis and its trend represents the rate of biological yield (biomass) accumulation. Analysis of variance for CGR at different growth stages in maize cultivars as affected by planting time is shown in Table 11 and Appendix Table 3. Crop growth rate did not vary significantly at V6 and R1 stages in all cultivars. The CGR of four maize cultivars increased progressively from V6 stage to R1 (silking) stage (Figure 3). The IES Glutinous-4 and MMSU cultivars had increasing CGR until to R4 (dough) stage, and decreased beyond R4 stage. On the other hand, the CGR of Supersweet plateaued at R1 (silking) and R4 (dough) stages, then decreased until R_6 (physiological maturity). The CGR of Sweet Jubilee-209 cultivar peaked at R_1 (silking), then declined until physiological maturity. Thus, the peak in CGR was recorded at R4 (dough) stage for IES Glutinous-4 and MMSU, while Sweet Jubilee-209 had lowest CGR as Sweet Jubilee-209 was not resistant to stem borers, especially within and after tasseling stage. The MMSU cultivar was the second highest in terms of CGR. The higher CGR obtained in IES Glutinous-4 and MMSU could be due to high number of leaves, taller plant stature, and large LAI (Table 11, Figure 3 and Appendix Table 3), suggesting that these cultivars can grow well under the Los Baños climatic condition regardless of planting time within the months of February to May.

The time of planting had significant effect on CGR at V_6 and R_1 growth stages but had no significant effect on R4 and R6 stages (Table 11, Figure 4 and Appendix Table 3). The April planting time had the lowest CGR from V_6 to R_4 stage. This could be due to unfavorable environmental condition which resulted in lower plant height with higher number of leaves, but relatively smaller leaves, and hence lowest LAI (1.5). Lower CGR was recorded in May planting, in spite the higher number of leaves and taller plants. This result could be attributed to the significantly low SR, high RH, and high rainfall during the growth periods which is favorable to stem borer infestation. The CGR of February planted crops was highest, although maize crops did not produce more leaves and received the least amount of rainfall, hence high SR and low RH, good height development and good leaf area development (although few in numbers) resulted to high LAI.

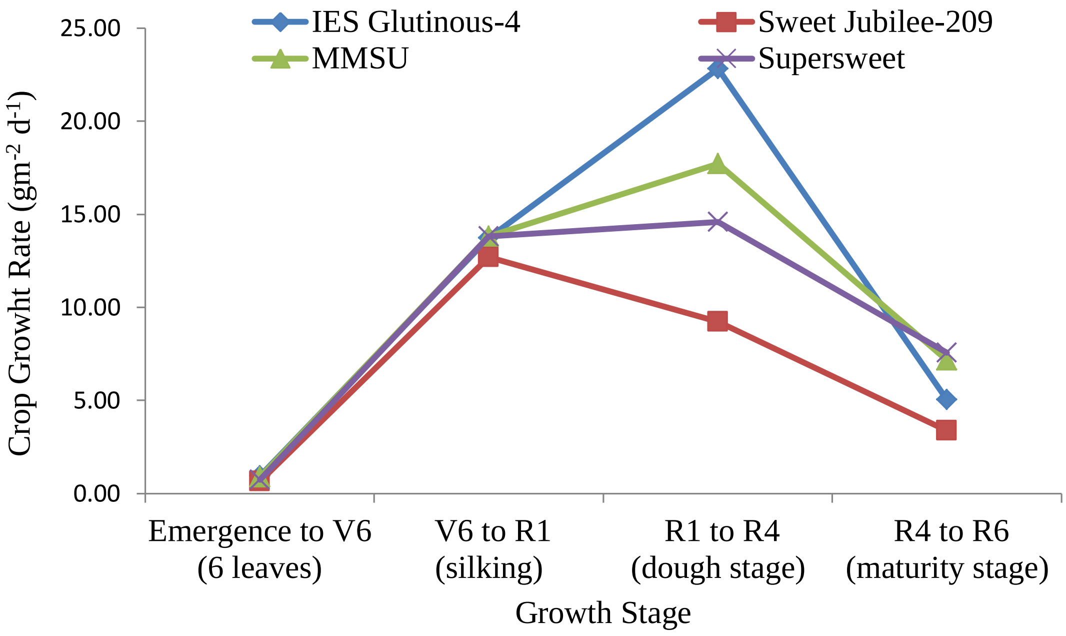


Figure 3 Trend of crop growth rates of four maize cultivars at different growth stages under Los Baños condition, 2016.(Vertical bars represent the standard errors.).

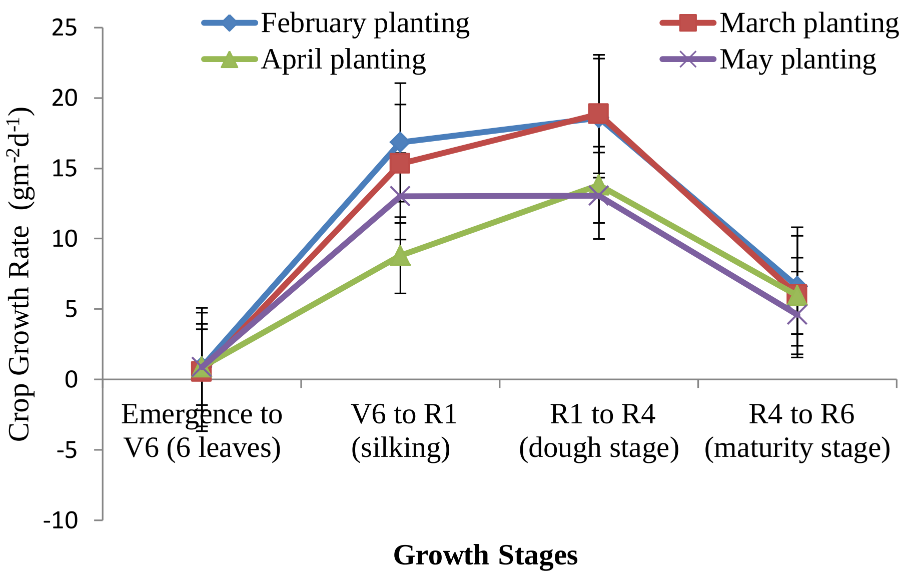


Figure 4 Trend of crop growth rates of four maize cultivars at different growth stages as affected by planting times (February-May) under Los Baños condition, 2016. (Vertical bars represent the standard errors.).

Table 11 Crop growth rate (CGR) of four maize cultivars at different stages as affected by planting time (February-May) under Los Baños condition, 2016

TREATMENT	**CROP GROWTH RATE (g m^{-2} d^{-1})**			
	Emergence to 6-Leaf	**6- Leaf to Silking**	**Silking to Dough**	**Dough to Physiological Maturity**
Cultivar(C)				
IES Glutinous-4	0.94	13.74	22.8 a	5.03
Sweet Jubilee-209	0.65	12.68	9.22 c	3.38
MMSU	0.88	13.80	17.7 ab	7.15
Supersweet	0.74	13.81	14.59 bc	7.56
Significance	**ns**	**ns**	**	**ns**
Planting Time (PT)				
February	0.89 a	16.85 a	18.56	6.59
March	0.54 b	15.34 ab	18.86	5.98
April	0.88 a	8.82 c	13.82	5.94
May	0.89 a	13.02 b	13.06	4.61
Significance	**	**	ns	ns
Interaction				
C × PT	**ns**	**ns**	**ns**	**ns**

Within the column, means with the same letter are not significantly different.
ns - non significant, * - significant at 5% level, ** - highly significant at 1% level

Total dry matter. Both cultivar and planting time treatments affected total dry matter accumulation (Table 8 and Appendix Table 2). Highest TDM (11528.7 kg ha^{-1}) was recorded in IES Glutinous cultivar, followed by MMSU with TDM (10337.9 kg ha^{-1}), by Supersweet (8498.89 kg ha^{-1}), while lowest TDM was observed in Sweet Jubilee-209 (6243.2 kg ha^{-1}). The trend in TDM accumulation was consistent with that of LAI (Table 8 and Figure 5). Then, CRFV negatively correlated with TDM at the vegetative stage (r = -0.57*) (Table 9). This shows that Sweet Jubilee-209cultivar was not adaptable to higher amount of rainfall during the period of vegetative stage. Moreover, CSRR positively correlated with TDM at reproductive in IES Glutinous-4, Sweet Jubilee-209 and Supersweet (r= 0.78**, r = 0.78** and r = 0.89**) (Table 9) while CRFR was not significantly correlated with TDM at reproductive stage (Table 12). The growth of IES Glutinous-4 and MMSU were more adaptable to varying growing environments as a result of different planting time within February to May. Although MMSU produced the least number of leaves (Table 8) with relatively shorter stature, MMSU cultivar appeared to be adapted to the February to May planting time.

The February plantings had the highest TDM with 11126.89 kg ha^{-1} followed by May planting (9891.0 kg ha^{-1}) and 11609.03 kg ha^{-1}, while April planting produced the least TDM (6606.6 kg ha^{-1}) (Table 8).This observation could be due to longer growth period in February planted crops, thus more solar radiation was received by the crop as compared to the April planted crops. This result was similar reported by Ahmed et al. (2011) in maize crops in Pakistan. In addition, CRFR positively correlated with TDM at reproductive stage (final harvest) (r = 0.67*) in February planted crops, but negatively affected on TDM at reproductive stage (final harvest) (r = -0.74**) in May planting time (Table 13). The highest TDM accumulation in the February planted crops could be due to the longer growth duration that allowed the maize crops to absorb more solar radiation for increasing photoassimilates. Thus the TDM of February planted crops was mainly partitioned to the leaf development (expansion of leaves) and increment in height, resulting to high LAI that is vital for photosynthesis. The relatively higher in May planted crops could be due to the production of more leaves, taller plant stature and high LAI. Hashemi Dezfuli et al. (1994) reported that variations in planting time may affect TDM production and yield, mainly due to alteration in growing period that may limit the capture of solar radiation. However, this was not observed in MMSU cultivar, having a short growing period, and it can be assumed that MMSU had the most adaptable canopy structure to absorb efficiently PAR.

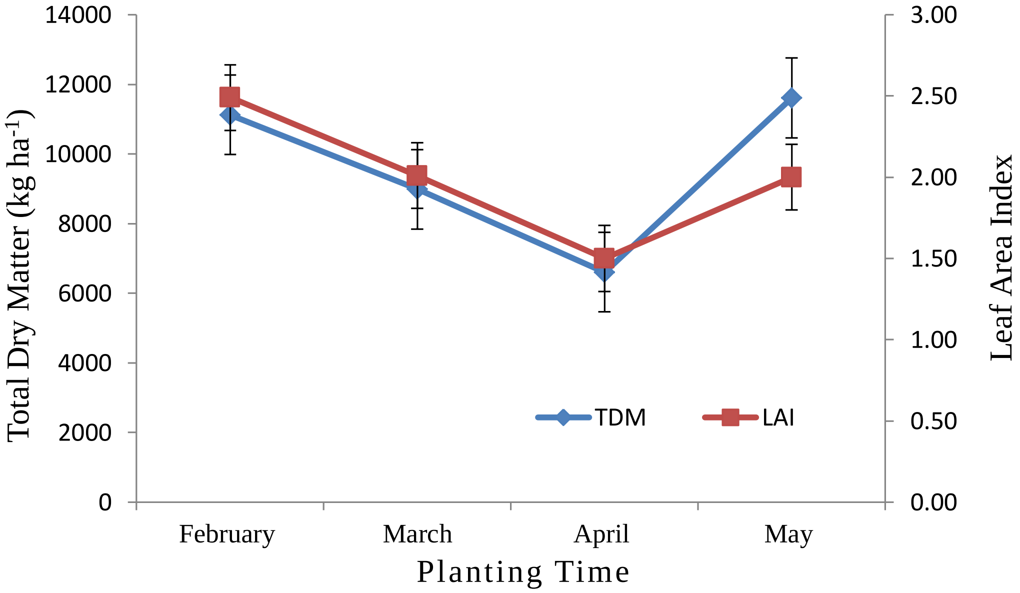


Figure 5 Leaf area index and total dry matter in maize crop at harvest as affected by varying planting times (February-May) under Los Baños condition, 2016. (Vertical bars represent the standard errors.)

Table 12 Correlation coefficient (r) generated based on the effect of climatic parameter and maize cultivars on the total dry matter accumulation at varying planting times (February-May) under Los Baños condition, 2016.

CORRELATION PARAMETER	**CULTIVAR**			
	IES Glutinous-4	Sweet Jubilee-209	MMSU	Supersweet
CSRR Vs TDM	0.78^{**}	0.78^{**}	0.52^{ns}	0.89^{**}
CRFR Vs TDM	-0.50^{ns}	-0.10^{ns}	0.33^{ns}	-0.44^{ns}

CSRR - Cumulative Solar Radiation at Reproductive Stage
CRFR - Cumulative Rainfall at Reproductive Stage
TDM - Total Dry Matter at Final Harvest

Table 13 Correlation coefficient (r) generated based on the effect of climatic parameter on the total dry matter accumulation of four maize cultivars at varying planting times (February-May) under Los Baños condition, 2016.

CORRELATION PARAMETER	PLANTING TIME			
	February	March	April	May
CSRR Vs TDM	0.41ns	0.33ns	0.37ns	0.54ns
CRFR Vs TDM	0.67^{*}	0.34ns	-0.09ns	-0.74^{**}

CSRR - Cumulative Solar Radiation at Reproductive Stage
CRFR - Cumulative Rainfall at Reproductive Stage
TDM - Total Dry Matter at Final Harvest

Harvest index (HI). Harvest index is one of the indices used to assess the efficiency of dry matter partitioning to economic yield in crops. Ratio of ear dry matter to plant total dry matter is related with the reproductive activities, and any negative effect on reproductive activities may decrease the ratio of ear dry matter to the plant total dry matter. Harvest index varied among cultivars and was significantly affected by planting time (Table 8 and Appendix Table 2). Highest HI (0.40) was obtained in MMSU cultivar, and the second highest HI (0.34) was observed in IES Glutinous-4, followed by Sweet Jubilee-209 (0.27), while the lowest was Supersweet (0.20). Moreover, in IES Glutinous -4, CSR positively correlated with HI ($r = 0.83^{**}$) and CRF negatively affected on HI ($r = -0.80^{**}$) while in MMSU, CRF also negatively correlated on HI ($r = -0.78^{**}$) (Table 13). These results indicates that dry matter partitioning in IES Glutinous -4 cultivar was more favored by CSR, but CRF was not favored to the dry matter partitioning to economic yield in both IES Glutinous -4 and MMSU cultivar.

The February planted crops had the highest HI (0.35), followed by the March and April planted crops (0.33 and 0.29, respectively). Lowest HI was recorded in May planted crops (0.25). Table 17 presents that CSR negatively affected on HI in all planting times from February to May ($r = -0.70^{*}$, $r = 0.63^{*}$, $r = -0.63^{*}$, and $r = -0.69^{*}$, respectively) while CRF negatively correlated with HI in March, April and May planting times ($r = -0.62^{*}$, $r = -0.61^{*}$, and $r = -0.73^{**}$, respectively). These results indicate that obtaining maximum HI in all planting times was limited by both CSR and CRF.

Yield Components

Analysis of variance and mean values for number of ears per m^2, number of kernels per m^2 (NK), kernel weight per m^2 (KW), and thousand kernel weight (TKW), are presented in Table (14) and Appendix Table (4).

Numbers of ears per m^2. The number of ears per m^2 varied among cultivars, but was not affected by planting time (Table 10 and Appendix Table 4). IES Glutinous-4 and MMSU produced the highest number of ears per m^2 (4.58), followed by Supersweet and Sweet Jubilee-209 (4.08 and 3.96 respectively). In MMSU cultivar, NE was positively affected by CRF (r = 0.62) (Table 14). The number of ears per m^2 was not affected by planting time although February and April planted crops had high number of ears per m^2 (4.42), relative to the May and March planted crops (4.21 and 4.12 ears m^{-2}, respectivelyThese results do not conform to Harris et al. (1984), and Otegui and Melon (1997) who reported that under temperate (France) conditions, the number of grains per ear and number of cobs per plant are affected by planting date. In addition, CSR negatively correlated with NE in May planting time (r = -0.76*) (Table 17). This shows that CSR (low in reproductive stage, Appendix Figure 3) in May planting time was not favorable for formation of kernels.

Number of kernels per m^2. The number of kernels per m^2 did not vary among cultivars, but was affected by planting time (Table 10 and Appendix Table 4). Even though there was no significant effect of cultivars, the highest NK was recorded in IES Glutinous-4 (1573.51), followed by Sweet Jubilee-209 (1544.72), MMSU (1535.61), and the least in Supersweet cultivar with 1519.01 kernels m^{-2}. In IES Glutinous -4 cultivar, moreover, CSR positively correlated with NK (r = 0.72**) while CRF negatively correlated with NK (r = -0.71**) (Table 14).

In this study, different planting time had significantly affected the number of kernels per m^2. The February planting gave the highest number of kernels m^{-2} (2010), followed by the March and May plantings that were statistically similar (1569.7 and 1440.3, respectively). The lowest number of kernels m^{-2} (1152.8) was observed in April planting. The higher number of kernels per m^2 in February planting could be explained by higher LAI and higher TDM obtained (Table 10). The favorable condition in the February planted crops could be due to high solar radiation, with optimum mean daily temperatures not greater than 32°C. The May planted crops on the other hand, were exposed to highest amount of rainfall, coupled by low solar radiation, particularly during reproductive and grain filling stages. Harris et al. (1984), and Otegui and Melon (1997) earlier observed that variations in planting date influence the number of grains per ear and number of cobs per plant.

Kernel weight per m^2. The kernel weight per m^2 varied in both cultivar and planting time treatments (Table 14 and Appendix Table 4). MMSU and IES Glutinous-4 cultivars did not differ in terms of kernel weight (415.4 and 402.9 g m^{-2}, respectively), but relatively higher thanSweet Jubilee-209 and Supersweet (186.3 and 184.5 g m^{-2}, respectively). The MMSU cultivar had the highest KW (415.4 g m^{-2}) while Supersweet had the lowest (184.5 g m^{-2}). Cultivar differences in terms of KW conforms to the generalization that the individual grain mass for a given cultivar is a stable character (Maddonni et al., 2004). Table 15 shows that CSR positively correlated with KW in IES Glutinous -4 (r = 0.67**) while CRF negatively affected on KW (r = -0.60*). This indicates that KW was more favored by CSR but CSR did not favor for KW in IES Glutinous -4.

Among the planting times, the highest kernel weight per m^2 was recorded in February planted crops (390.8 g m^{-2}), followed by March and May planted crops (296.2 and 287.5 g m^{-2}, respectively) (Table 14). The lowest kernel weight per m^2 was observed at the April planted crops (214.63 g m^{-2}). These results indicate that variation in kernel weight per m^2 is connected with the LAI, TDM and KN development which are highly affected by planting time. Stewart and Dwyer (1999) observed earlier that LAI and the distribution of leaf area within a maize canopy are major factors in determining total light interception, which affects photosynthesis, transpiration and dry matter production. The delayed planting from March to May, aside from exposure to lower cumulative solar radiation, maize crops had shorter growth duration due to relatively higher temperature during their vegetative stage, and relatively higher rainfall during reproductive stage, that affect the growth parameters (PH, LAI) that are major determinants of TDM and yield components, such as kernel weight. Then, in April planting time, CSR negatively correlated with KW ($r = -0.47^{*}$) while both CSR and CRF negatively affected on KW of maize crops planted in May ($r = -0.75^{**}$, $r= -0.83^{**}$, respectively) (Table 16).These results indicate that CSR and CRF were limited to KW in April and May planting times. Killi and Altanbay (2005) also observed that grain weight is significantly influenced by planting dates.

Table 14 Number of ears per m^2 (NE), number of kernels per m^2 (NK) and kernel weightper m^2 (KW) in maize cultivars as affected planting time (February-May) under Los Baños condition, 2016.

TREATMENT	YIELD COMPONENT			
	NE (Ears m^{-2})	NK (kernels m^{-2})	KW (g m^{-2})	GY (kg ha^{-1})
Cultivars (C)				
IES Glutinous	4.58 a	1573.51	402.92 a	4047 a
Jubilee	3.96 b	1544.72	186.32 b	1879 b
MMSU	4.58 a	1535.61	415.4 a	4160 a
Supersweet	4.08 b	1519.01	184.51 b	1871 b
Significance	*	**ns**	**	**
Planting Time (PT)				
February planting	4.42	2010.03 a	390.8 a	3928 a
March planting	4.17	1569.72 b	296.19 b	2981 b
April planting	4.42	1152.78 c	214.63 c	2159 c
May planting	4.21	1440.33 bc	287.55 b	2888 b
Significance	ns	**	**	**
Interaction				
C × PT	ns	ns	ns	ns

Within the column, means with the same letter are not significantly different.
ns - non significant, * - significant at 5% level, ** - highly significant at 1% level

Thousand kernel weight. Thousand kernel weight significantly differed in maize cultivars but not affected by planting time. The interaction effect of cultivar and planting time was also non-significant (Table 14 and Appendix Table 4). Highest TKW was recorded in IES Glutinous-4 and MMSU (255.32 and 269.82 g, respectively), followed by Sweet Jubilee-209 and Supersweet (118.79 and 118.77 g respectively).

Although planting time did not effect on TKW, it appeared that February planting produced the highest TKW of 200.72 g, followed by the May, March and April plantings (198.66, 186.17 and 177.15 g, respectively) (Table 14). The thousand kernel weight resulting from delayed sowing from February planting to April planting was probably due to the decrease in translocation of photosynthates to the ripening grain (Rahman et al., 2001) and low daily incident radiation Cirilo and Andrade (1996), which is consistent with findings of Ahmad et al. (2007) and Khan et al. (2002).

Generally, MMSU produced the highest yield and yield components (ears per m^2, kernel weight per plant), except in number of kernels per m^2, while Supersweet was the lowest. The February planted crops performed best while the April planted crops was the least productive. This could be explained by the exposure of February planted crops to lowest amount of rainfall, and high amount of cumulative solar radiation, especially at the reproductive stage, while the April planted crops were exposed to low daily solar radiation (14.79 MJm^{-2}) and high amount of rainfall during the reproductive stage.

Table 15 Correlation coefficient (r) generated based on the effect of climatic parameter and maize cultivars on the yield components and yield at varying planting times (February-May) under Los Baños condition, 2016.

CULTIVAR	CLIMATIC PARAMETER	PARAMETER				
		HI	NE	KN	KW	Y
IES Glutinous-4	CSR	0.83**	-0.05^{ns}	0.72**	0.67*	0.68*
	CRF	-0.80**	0.03^{ns}	-0.71**	-0.66*	-0.66*
Sweet Jubilee-209	CSR	0.19^{ns}	0.37^{ns}	0.09^{ns}	0.01^{ns}	0.01^{ns}
	CRF	-0.56^{ns}	-0.30^{ns}	-0.35^{ns}	-0.31^{ns}	-0.31^{ns}
MMSU	CSR	0.54^{ns}	-0.78**	0.32^{ns}	0.29^{ns}	0.30^{ns}
	CRF	-0.78**	0.62*	-0.23^{ns}	-0.08^{ns}	-0.10^{ns}
Supersweet	CSR	0.45^{ns}	0.51^{ns}	0.40^{ns}	0.47^{ns}	0.47^{ns}
	CRF	-0.37^{ns}	-0.37^{ns}	-0.32^{ns}	-0.41^{ns}	-0.41^{ns}

CSR - Cumulative Solar Radiation for the whole planting time

CRF - Cumulative Rainfall for the whole planting time

HI - Harvest Index, NE - Number of ears per m^2,KN - Number of kernels per m^2

KW - Kernel weight per m^2, GY - Grain Yield per m^2

Table 16 Correlation coefficient (r) generated based on the effect of climatic parameter on the yield components and yield of four maize cultivars at varying planting times (February-May) under Los Baños condition, 2016.

PLANTING TIME	CLIMATIC PARAMETER	YIELD AND YIELD COMPONENT				
		HI	**NE**	**KN**	**KW**	**Y**
February	CSR	-0.70*	0.07^{ns}	0.17^{ns}	-0.35^{ns}	-0.34^{ns}
	CRF	-0.54^{ns}	0.19^{ns}	0.03^{ns}	-0.07^{ns}	-0.06^{ns}
March	CSR	-0.63*	0.11^{ns}	0.10^{ns}	-0.04^{ns}	-0.05^{ns}
	CRF	-0.62*	0.25^{ns}	0.24^{ns}	-0.02^{ns}	-0.02^{ns}
April	CSR	-0.63*	-0.20^{ns}	-0.04^{ns}	-0.47*	-0.47^{ns}
	CRF	-0.61*	-0.26^{ns}	-0.02^{ns}	-0.44^{ns}	-0.43^{ns}
May	CSR	-0.69*	-0.76**	-0.41^{ns}	-0.75**	-0.75**
	CRF	-0.73**	-0.84**	-0.43^{ns}	-0.83**	-0.82**

CSR - Cumulative Solar Radiation for the whole planting time

CRF - Cumulative Rainfall for the whole planting time

HI - Harvest Index, NE - Number of ears per m^2, KN- Number of kernels per m^2

KW - Kernel weight per m^2, GY - Grain Yield per m^2

Productivity of Maize Cultivars as Affected by Planting Time (kg ha^{-1}, 14 % MC)

Maize yields considerably differed among cultivars and planting time (Table 17). IES Glutinous-4 and MMSU had highest GYs (4046.9 and 4160.4 kg ha^{-1}, respectively), followed by Sweet Jubilee-209 and Supersweet (1878.7 and 1870.5 kg ha^{-1} respectively). For MMSU cultivar, both CSR and CRF did not significantly affected on GY, but CRF negatively correlated with HI and NE, and CSR negatively correlated with NE (Table 15). This finding shows that low amount of rainfall was required to increase HI and NE in MMSU cultivar. The high CSR that exceeds the optimum amount could limit the NE in this cultivar. For IES Glutinous-4 cultivar, both CSR and CRF significantly affected on GY wherein CSR positively correlated with GY ($r = 0.68^{*}$) while CRF negatively affected on GY ($r = -0.66^{*}$) (Table 15). This means that CSR was the important climatic factor for higher GY of IES Glutinous-4 cultivar because CSR positively correlated with HI, NK and KW. Then, TDM at final harvest was positively favored by CSRR. The CRF was significantly influenced on GY as this climate factor negatively correlated with HI, NK and KW.

February planted crops had the highest yield (3928 kg ha^{-1}), followed by the March and May planted crops (2981 and 2888 kg ha^{-1}, respectively) (Table 17). Lowest yield (2159 kg ha^{-1}) was obtained in April planted crops (Table 17). Results showed that the planting time significantly affected on maize yield. February planted maize crops had relatively high number of leaves, taller stature and high LAI attributed by high cumulative solar radiation, low daily RH and low amount of rainfall received during the growth period. The effect of favorable climatic elements was apparent in high CGRs and TDM accumulation in February planted crops. Moreover, major problem of water-logging due to heavy rainfall did not affect the February planted maize crop instead supplemental irrigation was applied as necessary. The April planted crops exposed to high temperatures, high rainfall and low cumulative solar radiation which are not favorable to biomass accumulation and yield formation. The results of the study conform with the finding of Hardman and Gunsolus (2002), who concluded that variations in planting time influence growth duration and yield of maize mainly due to variation in intercepted solar radiation. Thus, the February planted crops had enhanced growth parameters that favored the development of yield components and the final yield of maize crops.

Productivity of February Planted Maize Cultivars

February planting produced the relatively tallest plants, with second highest in terms of leaf number, highest LAI, and second highest total dry matter (Table 8). The maize crops planted on February had the highest yield among the four planting time treatments. The dominant environmental meteorological characteristics of the February planting were: lowest rainfall of 112.8 mm (least rainy days, Appendix Figure 2), highest cumulative solar radiation of 1734.6 MJ m^{-2} (lower daily temperature during vegetative stage) (Appendix Figure 3) and a RH of 79.9 % (Figures 6 and 7). This climatic regime produced the relatively lowest leaf number, but well expanded and high LAI. In spite of having received the lowest amount of rainfall, supplemental irrigation was applied as necessary, thus the highest amount of solar radiation with prevailing lower humidity enhanced the leaf development of the February planted crops. In addition, these environmental conditions were not favorable to disease developments. Therefore, the February planted maize crops produced the highest yield (3928 kg ha^{-1}) due to the relatively higher amount of incident solar radiation with longer growth duration which was attributed by relatively lower mean daily temperature especially at the vegetative growth stage.

Table 17 Grain yield (GY) of maize cultivars as affected planting time (February-May) under Los Baños condition. 2016.

TREATMENT	GRAIN YIELD (kg ha^{-1}, 14% MC)
Cultivars (C)	
IES Glutinous-4	4047 a
Sweet Jubilee-209	1879 b
MMSU	4160 a
Supersweet	1871 b
Significance	**
Planting Time (PT)	
February	3928 a
March	2981 b
April	2159 c
May	2888 b
Significance	**
Interaction	
C × PT	ns
LSD$_{0.05}$	617.15
Mean	2989.15
CV%	24.76

Means followed by the same alphabet do not differ significantly at 5% level.
ns - non significant, * - significant at 5% level, ** - highly significant at 1% level

Moreover, the correlation data for this planting time shows that cumulative solar radiation during vegetative stage (CSRV), and cumulative rainfall during vegetative stage (CRFV) positively correlated with growth parameters, such as NL and PH (Table 10), while CSR negatively affected on HI of maize crops in February planting time (Table 16). However, both CSR and CRF did not significantly attribute to the GY. This finding indicates that the climatic parameter in February planting were favorable for growth parameters for improving yield components in spite the decrease in partitioning of dry matter for sink capacity. Thus, the February planted crops had best crop growth rates (CGR) across different growth stages. This finding was consistent with many earlier authors who concluded that the observed LAI and distribution of leaf area within a maize canopy, which are the major factors for light interception, photosynthesis, transpiration and dry matter production (Stewart and Dwyer, 1999), increase in photosynthetic rate per plant (Edmeades and Daynard, 1979), and enhanced plant growth rate (Andrade et al., 1993). Hence, the February planted crops had the highest productivity relative to March, April and May planted crops.

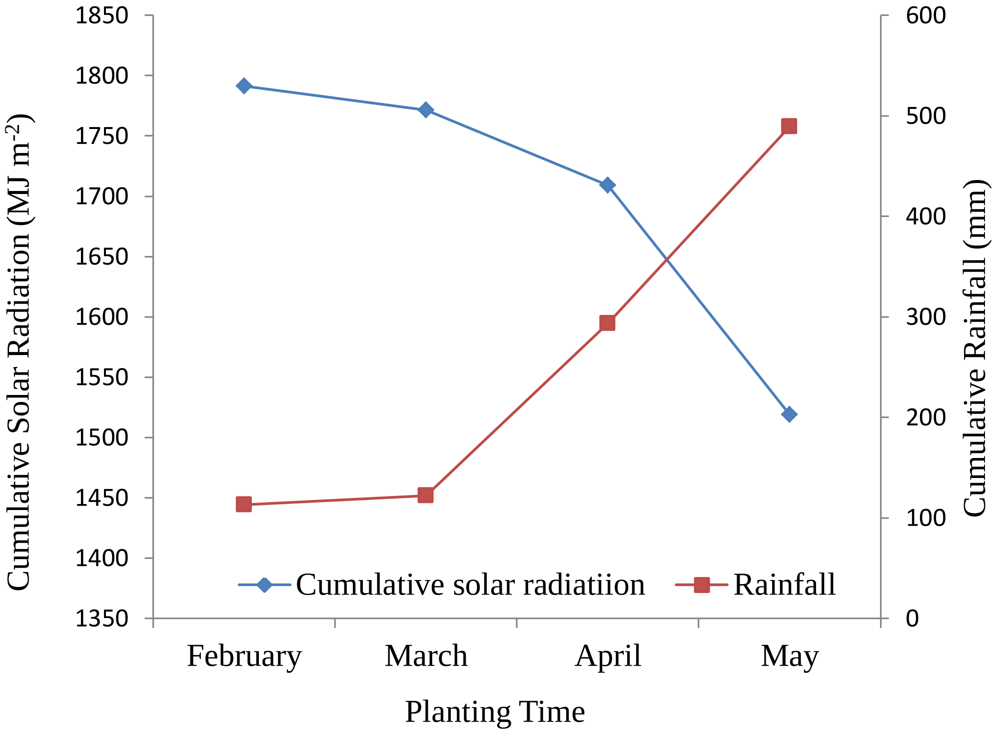


Figure 6 Cumulative rainfall and solar radiation during crop cycle as affected by varying planting time (February- May) under Los Baños condition, 2016.

Productivity of March Panted Maize Cultivars

The growing environment for March planted crops was little bit higher amount of rainfall and lower cumulative solar radiation relative to February planted crops (Figure 6). Mean maximum and minimum daily temperatures were a little bit higher in March planting relative to February planting (Table 3, Appendix Figure 3). Accordingly, the March planting time was relatively drier than February planting time in spite of the higher amount of rainfall. This environmental condition may have reduced the growth duration of maize cultivars, and so decrease the productivity of maize cultivars. Generally, the March planted crops had the second highest mean maize yield (2980.9 kg ha^{-1}) relative to the February, April and May planted crops (Table 17). Regarding the relationship between climatic parameters, and growth, yield components and yield, both CSR and CRF negatively correlated with HI, but did not significantly affected on GY of maize crops (Table 17). Regarding CRF, two heavy rainy days (20-22 mm, Appendix Figure 3) caused water-logging problem, and so reduced the growth parameters. The cops planted in March intercepted relatively high amount of solar radiation with high daily maximum temperature in the vegetative stage (Appendix Figure 2 and 3). Thus, relatively drier environment in the vegetative stage and water-logging can reduce the growth and yield components, and reduce the dry matter partitioning to the economic yield of crops that decrease GY.

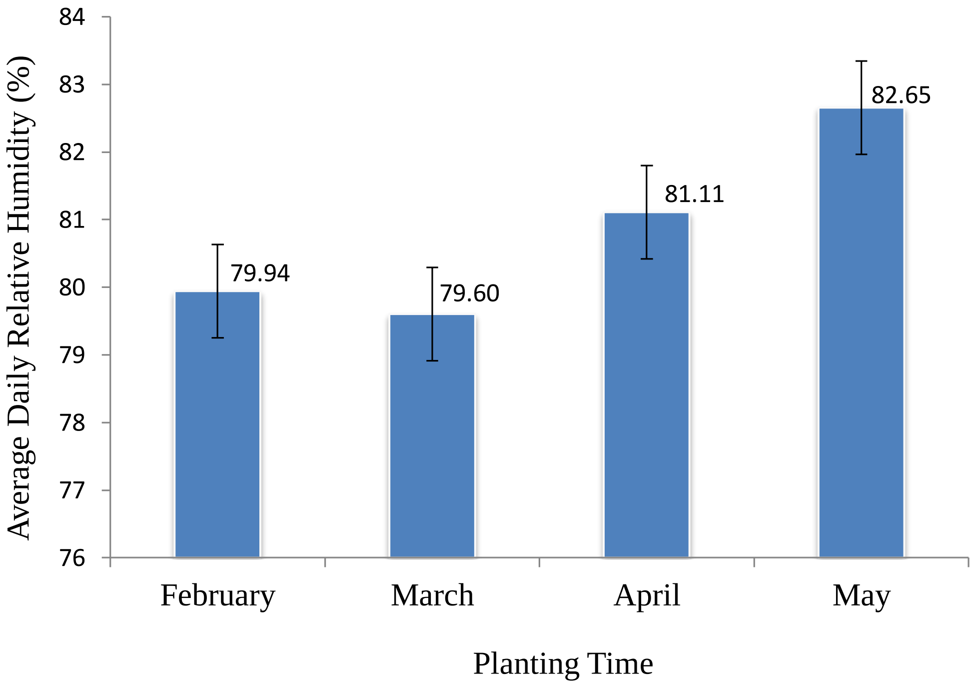


Figure 7 Average daily relative humidity during crop cycle as affected by varying planting time (February- May) under Los Baños condition, 2016.

Productivity of April Planted Maize Cultivar

The April planted crops were exposed to higher amount of rainfall that is more or less twice at reproductive stage than that at the vegetative stage, had significantly higher RH, which is associated with lower amount of cumulative solar radiation received relative to February and March planted crops. April planted maize crops were also exposed to higher RH during reproductive stage relative than the vegetative period. Due to smaller amount of cumulative solar radiation, higher daily maximum temperature (Appendix Figures 2 and 3), higher amount of rainfall, and high amount of RH (Table 3), in April planted crops, lowest LAI, lowest crop growth rate, and the lowest maize grain yield were attained shortening growth duration (2159 kg ha^{-1}) (Table 17). Then, CSRV and CRFV positively correlated with NL, but both CSR and CRF negatively correlated with HI (Table 15 and 17) although there was no significant effect of climatic parameters on GY.The reason could be due to relatively higher temperature at vegetative stage (Appendix Figure 4), and so this condition can limit the yield components. This observation however, is not consistent with the findings by Cirilo and Andrade (1994) under the temperate condition (France), in which high solar radiation interception and radiation use efficiency (RUE) resulted in high crop growth rates during the vegetative period, but conversely crop growth rates during grain filling because of low incident radiation and RUE. Maddonni et al. (2004) found that late plantings under temperate condition, both solar radiation and temperature are lower during grain filling, thus reduced solar radiation, source limitation.

Productivity of May Planted Maize Cultivars

Maize planted in May were exposed to the lowest amount of cumulative solar radiation (1518.8 MJ m^{-2}), and highest amount of rainfall (489.5 mm) (Table 3 and Appendix Figure 2). The condition during this growing period resulted to high number of leaves, taller plants and high LAI. Thus, May planted crops were exposed to favorable condition for production of biomass as reflected on the highest total dry matter (TDM). Consistently, the May planted maize crops were exposed to the highest mean daily RH that favored disease development, and crop lodging due to heavy rainfall. The number of grains per plant in the May planted crops was relatively low (third) but the third and the second highest in terms of grain weight. Generally, the May planted crops had lower yield (2888 kg ha^{-1}) than the February and March planted crops.

In the May planting time, CSRV positively affected on NL (Table 9). This indicates that daily solar radiation at vegetative stage was favorable for leaf production. However, CRFV negatively affected on TDM at the end of vegetative stage and both CSR and CRF negatively correlated with HI, NE and KW (Table 17). Thus, CSR and CRF negatively correlated with GY ($r = -0.75^{**}$, $r = -0.82^{**}$, respectively) (Table 17). This indicates that daily solar radiation at vegetative stage was favorable for leaf production, while amount of rainfall at both vegetative and reproductive stage were least favorable for intercepting solar radiation, and retarding yield components, thus reduced the GY. Thus, the relatively high amount of rainfall received at both vegetative and reproductive stage could have also limited to TDM accumulation and HI. Therefore, the yield reduction, in spite the high NL, PH, LAI, TDM, may be attributed by CSRV and amount of higher cumulative rainfall at both vegetative and reproductive stages by decreasing the photosynthetic efficiency of maize plants, and causing pest infestation and waterlogging and lodging problem. This result is supported by Andrade et al., (2002) who concluded that the capacity of the crop to intercept photosynthetically active radiation and synthesize carbohydrates for growth is a nonlinear function of LAI (Andrade et al., 2002). Then, Shaw (1988) reported that although maize is grown in areas that receive annual rainfall of more than 500 cm, extreme rainfall can damage maize crop, especially with water-logging problem (Shaw, 1988).

CHAPTER V

GENERAL DISCUSSION

The grain yield formation in maize is a function of proportional contributions of effective factors from emergence to maturity. Hence, it is necessary to understand the effect of climatic and cultural practices on maize yield. Maize grain yield can be described as a function of the rate and duration of dry matter accumulation by the individual kernels, multiplied by the number of kernels per plant (Westgate et al., 1997). In simple terms, Hatfield et al. (1984) stated that maize grain yield is a product of the number of ears produced and the average weight of grain in the ears. Anything that affects one or both of these factors will significantly affect the final maize yield. According to Hashemi et al. (2005), grain yield per unit area is the product of grain yield per plant and number of plants per unit area. In the present study, varying planting time (February-May planting) significantly affected the crop phenology, growth parameters, yield and yield component parameters of four maize cultivars. The differential response of maize cultivars is associated with variations in CSR and CRF during maize growth brought about by the different planting time.

Environmental factors, especially solar radiation and rainfall, are the key agents which affected maize plant growth and development and grain yield. Significant differences among different maize cultivars from emergence to physiological maturity show that different cultivars had varying maturity periods, variations in the account of intercepted solar radiation due to varying planting time. The MMSU cultivar had the shortest duration for each of the growth stages. Supersweet cultivar on the other hand, had the longest duration for each growth stage. This implies that the number of days to reach each growth stage is genotype specific. Moreover, the tested maize cultivars showed well respond to different climatic parameters especially mean daily temperature, solar radiation and rainfall within varying tested planting times. The planting time significantly affected the number of days to V6, days to tasseling, silking and physiological maturity in maize cultivars planted within February to May 2016. The effect of planting time on the duration of phenological stages of maize cultivar is attributed to the differences in cumulative solar radiation and the amount of rainfall received by the crops planted at different months. Cumulative solar radiation and rainfall differences during the period from seed development to maturation, have affected crop phenology, and growth parameters yield components and yield of each cultivar within each planting time. Thus, there was significant decrease of yield when planting was delayed from February to April 2016. This response is due to the decrease in photosynthetic rate per plant as a function of CSR and LAI, which is reflected on the crop growth rate.

In this study, planting time had significant effect on number of leaves, plant height, and total dry matter, but not on the LAI and HI, yield. For yield components, only ears per m^2 and kernel weight more affected. The February planting gave the highest grain yield. High grain yield in this planting month is attributed to plant stature, long growth duration and highest LAI despite the low number of leaves per plant observed. This implies that the leaf distribution and development was under the favorable climatic condition (SR and RF) that increased source capacity of photosynthetic efficiency, and longest growth duration efficiently increased the intercepted PAR for higher source capacity. The amount of intercepted solar radiation and rainfall at both vegetative and reproductive stages at February planting time were positively favorable for good growth parameters of maize crops, such as NL and PH maximizing TDM accumulation which resulted to higher GY. Moreover, this planting time did not receive heavy rainfall during critical reproductive stage apart from lodging, and so produced the highest GY of maize cultivar. Thus, February planting had relatively higher LAI and total dry matter that efficiently supported the developments of sink organs (yield components). While February planting time had the lowest amount of rainfall, irrigation was done, hence, water is not limiting.

Delayed sowing in March and April, resulted in significant reduction in plant height, LAI, total dry matter, grain number per plant, kernel weight, and growth duration. Thus, lower grain yield was obtained when maize crops were planted in March and April. April planting is characterized by dry growing environment, with highest monthly maximum temperature, relatively lower SR but higher amount of rainfall during reproductive and grain filling stages. Generally April planting resulted to shorter growth duration, and most variation in growing climatic condition that may have interrupted maize plant physiological processes (photosynthesis, assimilate partiotioning) during reproductive and grain filling stages. Thus, the April planting had lowest number of leaves and shortest plant stature, least LAI, least CGR and least TDM produced. These responses in growth parameters, was different in reduced number of ears per m^2, number of kernels per m^2, and kernel weight per m^2. Moreover, the water-logging problem was very difficult to control as the experimental field has high clay content. Therefore, the maize cultivars planted in April had the lowest grain yield.

The May planted crops gave the highest leaf numbers, relatively tall and higher LAI, which resulted to highest total dry matter yield and relatively higher CGR. These vegetative growth parameters were due to favorable high RH and RF during vegetative stage. The correlation tables show that, the relatively lower in CSR and cumulative rainfall (CRF) during reproductive stage were the limiting climatic factors in May planted crops pest infestation (stem borer), that decreased the grain yield productivity of the May planted crops. However, Lizaso et al. (2003) observed earlier that the average absorbed photosynthetic active radiation (PAR) by leaf area at reproductive stage is the determining factor for maize yield, and grain yield in higher correlation with leaf area. In May planting, yield could be attributed to crop lodging and pest infestation, which brought about by low CSR and high RH at post-reproductive stage.

Moreover, the number of ears per unit area was significantly varied with cultivars, while not affected by planting time. IES Glutinous and MMSU had the highest number of ears per unit area. This implies that IES Glutinous and MMSU were adaptable to the growing environment in the February planting, in which highest number of ears per unit area was recorded.

Planting time had the significant effect on the KN. In the present study, more grains were produced. The greater grain numbers were produced by the treatments with higher LAI and TDM. These favorable conditions in February and the March plantings could be mainly due to high solar radiation and moisture content during the vegetative and reproductive stage. The May planted crops on the other hand were exposed to highest amount of rainfall and low solar radiation which are favorable for vegetative growth, but negatively affected growth and development during reproductive stage.

The LAI with delayed planting from February to April increased in May planting. This trend in LAI was also observed in TDM, GN GW parameters. Stewart and Dwyer (1999) reported that LAI and distribution of leaf area within a maize canopy are major determinants of light interception that affects photosynthesis, transpiration and dry matter production. Andrade (1995), and Killi and Altanbay (2005) also observed that grain weight is significantly influenced by planting dates.

The highest KW was produced by MMSU in the February planting date. The KW trend was consistent with the observed grain yield, particularly attributed to the highest cumulative solar radiation during the whole growing period of the crop, particularly during the reproductive stage. Conversely May planting had the lowest cumulative solar radiation, highest amount of rainfall, and highest number of rainy days during the reproductive period which may have reduced the radiation use efficiency. This finding is in agreement with Cirilo and Andrade (1994) who concluded that plants exposed to low radiation and low temperature during reproductive and grain filling stages have low dry matter production and grain yield.

CHAPTER VI

CONCLUSION

Planting date is one of the key points in crop management to optimizing productivity. This study provides new information about the effect of four different planting times in four maize cultivars grown under Los Baños condition.

Plant height, LAI and dry matter yield were affected by both planting date and cultivars. Varying crop responses were observed with different planting time. February planting was found to be the most productive (relative to March, April and May plantings). This was due to high leaf area development (LAI), CGR, TDM productivity and favorable development of yield components brought about high cumulative solar radiation, low RH and low rainfall (but irrigation was provided). Delaying the planting date from February to April had a negative effect on the leaf development, and height development resulting to lower LAI and shortened growth duration of maize cultivars. Thus delay in planting date from February to April caused decreasing trend in CGR and TDM, negatively affected the yield components, grain yield of the maize cultivars.

MMSU cultivar consistently out-performed the other cultivars in terms of growth parameters, yield components and grain yield across four planting times despite having the shortest growing period. Thus, MMSU could be a good cultivar for off-season planting, i. e. with March, April and May.

For higher productivity, moreover, MMSU should be grown in the month of February, but not later than March so that this cultivar will be exposed to high amount of the solar radiation, with the supplemental irrigation considering the low amount of rainfall in this planting time under Los Baños condition. April and May planning of maize Los Baños condition should be avoided due to high occurrence of rainfall, and low solar radiation during reproductive and grain filling stages. Crop lodging and pest-infestation would be the other yield-limiting factors in these planting months.

LITERATURE CITED

AHMAD, M., HUSSAIN, N., JAN, A., AHMAD, K. and HUSSAIN, S. (2007). Response of maize to P levels and plant density.Sarhad J. Agric. 23(1): 69-73.

AHMADI, M., WIEBOLD, W.J., BEUERLEIN, J.E., ECKERT, D.J. and SCHOPER, J., (1993). Agronomic practices that affect corn kernel characteristics. Agron. J. 85, 615-619.

AHMED, A., F. MUNSIF, M. ARIF, INAMULLAH and M. NUAMAN.(2011). Yield and yield components of maize as affected by sowing dates and sowing methods. FUUAST J. BIOL., 1(1): 75-80

AKBAR, M., S. SHAKOO, A. HUSSAIN and M. SARWAR. (2008). Evaluation of maize 3-way crossed through genetic variability, broad sense heritability, characters association and path analysis. J. Agric. Res., 46: 39–45.

ANDRATA F. H., S. D. UHART and M. I. Frugone, (1993). Intercepted radiation at flowering and kernel number in maize, shade versus plant density effects. Crop Sc., 33: 482-485.

ANAPALLI S.S., L. MA. D. C. NIELSEN, M. F., VIGIL and L. R., AHUJA. (2005). Simulating planting date effects on corn production using RZWQM and CERES-Maize models. Agronomy J 2005; 17(97): 58-71.

ANLEY, W., H. ZELEKE and Y. DESSALEGN. (2013). Genotype X environment interaction of maize (Zea mays L.) across North Western Ethiopia Workie.Vol,5(9), pp. 171-181, DOI: 10.5897/JPBCS2013.0406. ISSN 2006-9758 ©2013 Academic Journals http://www.academicjournals.org/JPBCS.

ARC-GCI, (2002).Maize information guide.ARC-Grain Crop Institute, Potchefstroom, South Africa. Pp. 31-38.

BEGNA,S.H., R.I. HAMILTON, L.M. DWYER, D.W. STEWART, and D.L. SMITH. (2000). Variability among maize hybrids differing in canopy architecture for aboveground dry matter and grain yield. MAYDICA, 45(2): 135-141.

BOLLERO, G. A., D. G. BULLOCK, and S. E. HOLLINGER (1996). Soil temperature and planting date effects on corn yield, leaf area and plant development. Agron. J. 88: 385-390.

CARRARETTO, M. (2005) Corn Story of Amerindian Divinity to Its Transgenic Avatars. Publishing Committee of Historical and Scientific Work, Paris, 56 p.

CHAUDRY, F. M. (1994). Kharif cereal crops in crop production by S. Nazir, E. Bashir and R. Bantle (eds). Natoinal Book Foundation, Islamabad, pp: 262.

CHOWDHURY, M. A. H. and M. S. HASSAN. (2013). Hand Book of Agricultural Technology.Bangladesh Agricultural Research Council, Farmgate, Dhaka, Bangladesh.

CHISANGA, C. B., E. PHIRI, E., C. SHEPANDE and H. SICHINGABULA. (2015). Evaluating CERES-Maize Model Using Planting Dates and Nitrogen Fertilizer in Zambia. Journal of Agricultural Science; Vol. 7, No. 3; ISSN 1916-9752 E-ISSN 1916-9760. p: 81.

CIRILO AG, ANDRADE FH (1994). Sowing date and maize productivity I. Crop growth and dry matter partitioning. Crop Sci. 34: 1039-1043.

DAUGHTRY, C.S.T., K.P. Gallo and M.E. BAUER, 1983. Spectral estimates of solar radiation intercepted by corn canopies. Agron.J., 527-531.

DU TOIT, A.S., M.A. PRINSLOO, W. DURAND, and G. KIKER. (2002). Vulnerability of maize production to climate change and adaptation in South Africa, Combined Congress: South AfricanSociety of Crop Protection and South African Society of Horticultural Science, Pietermaritsburg (SA).

DEVI, K.B.S., and V.P. Rao. (2002). Growth and yield sensitivity of corn (ZeamaysL.) to evapo-transpiration deficits. J. Soils and Crops 12:6-10.

DWYER, L. M., R.I. HAMILTON, H.N. HAYHOE and S.W.ROYD.(1991). Analysis of biological traits contributing to grain yield of short to mid – season corn hybrids.Canadian Journal of Plant Science .71:535 – 541.

EVANS, L.T. (1993). Processes, genes and yield potential. In Buxton, D.R., Shibles, R., Forsberg, R.A., Blad., B.L., Asay, K.H., Paulsen, G.M., and Wilson, R.F. (Eds), International crop science, Voulme 1 (pp-68-701), Madison, WI: CSSA.

ECKERT, D. (1995). Corn production in Ohio.http://ohioline.osu.edu/b472/.htm

EDMEADES, G. O., N. A. FAIREY, and T. B. DAYNARD. (1979).

FAO (2002).Fertilizer and the Future.IFA/FAO Agriculture Conference on Global Food Security and the Role of Sustainability Fertilization, Rome, 16-20 March 2003, 2 p.

FAO. (2014). How will climate change affect food security? Mitigating the effects on agriculture will require creative adaptations, per IPCC report. Kloeke, E. van. O., December, Elsevier .com/connect/how-will-climate-change-affect-food-security.

FOLLETT, R.F., L.C. BENZ, E.J. DOERING, and G.A. REICHMAN.(1978). Yield response of corn to irrigation on sandy soils.Agron. J. 70:823-828.

GARDNER, F.P., PARCE, R. and MITCHEL, R.L. (1985).Carbon fixation by crop canopies. Physiology of Crop Plants: 31-57.

GRAFIUS, J.E. 1960. Does over dominance exist for yield in corn? Agronomy Journal 52: 361.

GRZESIAK, S. (2001).Genotypic variation between maize (ZeamaysL.) single-cross hybrids in response to drought stress.ActaPhysiologiaePlantarium J., 23(4), 443-456.

HANWAY, J. J. (1966). Irrigation. p. 155-176. InW.H. Pierre et al. (ed) Advances in corn production: Principles and practices. Iowa State Univ. Press, Ames, IA.

HARDMAN, L.L., and J.L. GUNSOLUS.(2002). Corn growth and development and managementinformation for replant decisions.Available at www.extension.umn.edu/distribution/cropsystems/DC5700.html (verified 14 July 2005). Univ. of Minnesota Extension Service, St. Paul, MN.

HASHEMI DEZFULI S., S. ALEMI and K. SYADAT. (2001). Effects of planting date on yield potential of two sweet maize hybrids in Khozestan condition. Iran Agricultural J., 32: 681-689.

HATFIELD, A.L., G.R. BENOIT and J. L. RAGLAND. (1984). The growth and yield of corn. IV. Environmental effects on grain yield components of mature ears. Agron. J. 57, 293-295.

HESKETH, J. D., and I. J. WARRINGTON, (1989). Corn growth response to temperature: rate and duration of leaf emergence. Agron. J. 81: 696-70.

IHSAN, H., I.H. KHALIL, H. REHMAN, and M. IQBAL.(2005). Genotypic Variability for morphological traits among exotic maize hybrids.SarhadAgric J., 21(4), 599-602.

JAFARI, M. (2010).Effect of planting date, irrigation intervals and nitrogen rates on morphological and yield of forage millet. M.Sc. Thesis on Agriculture, IslamicAzad University, Birjand Branch, Iran, pp. 113.

JOHNSON, R. R., and D. L. MULVANEY.(1980). Development of a model for use in maize replant decisions. Agronomy Journal, 72: 459-464.

KHAN, N., M. QASIM, F. AHMED, F. NAZ, and R. KHAN. (2002). Effect of sowing dates on yield of maize under agro-climatic condition of Kaghan valley. Asian J. Plant Sci. 1(2): 146-147.

KHAN, H., M. ARIF, R. GUL, N.AHMAD and I. A. KHAN. (2002). Effect of sowing dates on maize cultivars. Sarhad J. Agric. 18(1): 11-15.

KILLI F, and S. G. ALTUNBAY. (2005). Seed yield, oil content and yield components of confection and oil seed sunflower cultivars (Helianthus annuus L) planted on different dates. Int. J. Agric. Biol. 7:21-24.

KUCHARIK.C.J., (2008).Contribution of planting date trends to increased maize yield in the central United States. Agronomy Journal.100:328-336.

LAMM, F.R., H.L. MANGES, L.R. STONE, A.H. KHAN and D.H. ROGERS.(1995). Water requirement of subsurface drip-irrigated corn in northwest Kansas. Transactions of the ASAE 38:441-448.

LAUER, J.G., P.R. CARTER, T.M. WOOD, G. DIEZEL, D.W. WIERSMA, R.E. RAND and M.J. MLYNAREK.(1999). Cornhybrid response to planting date in the Northern Corn Belt.Agron. J. 91, 834-839.

LIZASO J. I., W. D. BATCHELOR, M. F. WESTGATE and L. ECHARTE. (2003). Enhancing the ability of CERES-Maize to compute light capture. Agric. Syst. 76: 293-311.

LUKEBA, J-C.L., R. K. VUMILIA, K. C. K., NKONGOLO, M. L., MWABILA and M. TSUMBU, 2013.Growth and Leaf Area Index Simulation in Maize (ZeamaysL.) under Small-Scale Farm Conditions in a Sub-Saharan African Region. American Journal of Plant Sciences; 4, 575-583; http://dx.doi.org/10.4236/ajps.2013.43075; Published Online March 2013 (http://www.scirp.org/journal/ajps.)

MADDONNI, G.A., M. E. OTEGUI, and R. BONHOMME, (2004). Grain yield components in maize: II. Postsilking growth and kernel weight. Field Crops Res. 56, 257-264.

MAJOR, D.J. and T.B. DYNARD.(1972). Hyperbolic relation between leaf area index and plant population in corn. Can. J. Plant Sci. 52, 112-115.

MAJOR, D.J., R.J. MORRISON, R.E BLACKSHAW and B.T. ROTH.(1991). Agronomy of dryland corn production in the Northern Great Plains. J. Prod. Agric. 4, 606-613.

MATZENAUER, R., H. BERGAMASCHI, and M. BERLATO, 1998.Evapotranspiracaodacultura do milho. RevistaBrasileiradeAgrometeorolgia. Santa. 6, 9-14.

MILANDER, JEREMY J, 2015. "Maize Yield and Components as Influenced by Environment and Agronomic Management" (2015). Theses, Dissertations, and Student Research in Agronomy and Horticulture. Paper 86.

MOKHTARPOUR, H., TEH, C.B.S., SALEH, G., SELAMAT, A.B., ASADI, M.E. and KAMKAR, B. (2010) Non-Destructive Estimation of Maize Leaf Area, Fresh

Weight, and Dry Weight Using Leaf Length and Leaf Width. Communications in Biometry and Crop Science, 5, 19-26.

MOURICE, S. K., C. L. RWEYEMAMU, S. D. TUMBO and N. AMURI, 2014.Maize Cultivar Specific Parameters for Decision Support System for Agrotechnology Transfer (DSSAT) Application in Tanzania. American Journal of Plant Sciences; 5, 821-833. http://www.scirp.org/j ournal/ajps, http://dx.doi.org10.4236/ ajps.2014.56096.

MUCHOW, R.C. (2000). Improving maize grain yield potential in the tropics; Physiological bases for Maize Improvement. p;47-70.

MUCHOW, R.C. and P. C. CABERRY.(1989). Environmental control of phenology and leaf growth in a tropically adapted maize.Field Crops Research. 20: 221-236.

NIELSON, R.L., P.R. THOMISON, G.A. BROWN, A.L. HALTER, J. WELLS, AND K.L. WUETHRICH.(2002). Delayed planting date effects on flowering and grain maturation of corn.Agronomy Journal, 94: 549- 558.

NOFERESTI M (2006). Effect planting date on yield and yield components of forage corn as second cultivation in Birjand, Iran region. M.Sc. Thesis on Agriculture, Islamic Azad University, Birjand Branch, Iran, pp. 103.

NORWOOD, C. A. (2001). Planting date, hybrid maturity and plant density effect on soil water depletion and yield of dry land corn.Agron J. 93: 1034-1042.

NOORMOHAMADI G., A.SYADAT and A. KHASHANI, (2001).Agronomy (cereal). Published by ShahidChamran Ahvaz University. Vol.1.

OKTEM, A. (2000). Determination of sowing dates of corn (*Zea mays* L. saccharata Sturt) under dryland conditions. Turkish Journal of Agriculture and Forestry. 21, 65-71.

OU-LEE, T.-M and T. L. SETTER.(1985). Effect of increased temperatures in apical regions of maize ears on starch-synthesis enzymes and accumulation of sugars and starch. Plant Physiology 79: 852-855.

OTEGUI, M.E.,G.N. MARIA, A.R. RICARDO, and A.D. PABLO. (1995). Sowing Date Effects on Grain Yield Components for Different Maize Genotypes. Agron. J. 87:29-3.

OTEGUI, M.E., and S., MELON. (1997). Kernel set and flower synchrony ´within the ear of maize: I. Sowing date effects. Crop Sci. 37, 441–447.

Philippine Council for Agriculture and resources Research (PCARR). 1981. The Philippines recommends for Corn 1981. Los Baños, Laguna.

RAGHEB, M.M. and H.N. RASSY.(1989). Response of some maize varieties to nitrogen fertilization. I. Vegetative growth and dry matter accumulation. Egypt. J. Agron. 12(1-2): 111-122.

RAJCAN, I., and C.J. SWANTON. (2001). Understanding maize-weed competition: Resource competition, light quality, and the whole plant. Field Crops Res. 71:139-150.

RAMANKUTTY N, J.A. FOLEY, J. NORMAN, K. MCSWEENEY, (2002). The global distribution of cultivable lands: Current patterns and sensitivity to possible climate change. Global Ecology Biogeogr. 13(11): 377-392. http://dx.doi.org/10.1046/j.1466-822x.2002.00294.x.

RANANDA, P. (2015). PH drops in 2016 list of countries vulnerable to climate change. http://www. rappler.com/science-nature/environment/113064- philippines- 2016-climate-change-vulnerability-index.

RAYMOND, F. D. (2007). Reducing Corn Yield Variability and Enhancing Yield Increases Through the Use of Corn-Specific Growth Models.

REYES, C.M., S. N. DOMINGO, C.D. MINA and K.G. GONZALES. (2009). Climate Variability, SCF, and Corn Farming in Isabela, Philippines: a Farm and Household Level Analysis. Philippine Institute for Development Studies (PIDs); DISCUSSION PAPER SERIES NO. 2009-06.

ROBINS, J.S., and H.F. RHODES.(1958). Irrigation of field corn in the west. USDA Leafl. 440. U.S. Gov. Print. Office, Washington, DC.

SABIR, M.R., I. AHMAD and M.A. SHAHZAD.(2000). Effect of nitrogen and phosphorus on yield and quality of two hybrids of maize (Zea mays L.). J. Agric. Res. 38(4): 339-346.

SÁRVÁRI, M., and Z. FUTÓ. (2000). Correlation between the sowing date, yield and grain moisture content of maize hybrids on chernozem soil. DebreceniEgyetemAgrártudományiKözlemények J., 1: 32-41.

SASEENDRAN, S.A., L.MA, D.C.NIELSEN, M.F.VIGIL and L.R.AHUJA (2005).Simulating planting date effects on corn production using RZWQM and CERES maize models. Agronomy Journal.97:58-71.

SHAW, R.H. (1977). Water use and requirements of maize - a review.p 199-134. In Agrometeorology of the maize crop.World Meterol. Org. Publ. 481. Secreteriat, WMO, Geneva, Switzerland.Hanway, J.J. 1966. Irrigation. p. 155-176.

SHAW, R.H. (1988). Climate Requirement.InC.F. Sprague, and J.W. Dudley (eds) Corn and Corn Improvement. ASA, Madison, WI.

STEWART, D.D. and L. M. DWYER, (1999).Mathematical characterization of leaf shape and leaf area of maize hybrids. Crop Sci. 39, 422-427.

STOOCKSBURY D. E. and P. J. MICHAELS. (1994). Climate change and large area maize yield in the South Eastern United State. Agron. J. 86:564-569.

TOLLENAAR, M. and A. AGUILERA.(1992). Radiation use efficiency of an old and a new maize hybrids.Agron. J. 84, 536-541.

TSIMBA R., (2011). Development of a Decision Support System to determine the best Maize (Zea mays L.) hybrid-planting date option under typical Newzealandmanagement systems (Ph. D Thesis). Massey University, Palmerston North, New Zeland.

VALERIO, A. T. (2014). Determinants of agricultural productivity of selected major crops in the Calabarzon region, Philippines. Global Business and Economics Research Journal, 3(7): 16-31.

VILLALOBOS, FJ, L. MATEOS, F. ORGAZ, and E. FERERES, (2002).Fitotecnia: Bases y tecnologías de la producciónagrícola. Mundi-Prensa; editor.496 p.In Solar Radiation Effect on Crop Production. Prof. Elisha B. Babatunde (Ed.), Campillo, C, R. Fortes and M. H. Fortes, (2002) 170:11-195, ISBN: 978-953-51-0384-4, InTech, Available from: http://www.intechopen.com/books/solar-radiation/solar-radiation-effect-on-crop-production.

WAJID, A., A. GHAFFAR, M. MAQSOOD, K. HUSSAIN and W. NASIM.(2007). Yield response of maize hybrids to varying nitrogen rates. Pak. J. Agric. Sci. 44(2): 217-220. InW.H. Pierre et al. (ed) Advances in corn production: Principles and practices. Iowa State Univ. Press, Ames, IA.

WELSH, J. (1981). Fundamentals of plant breeding and genetics. John Wiley & Sons, New York.

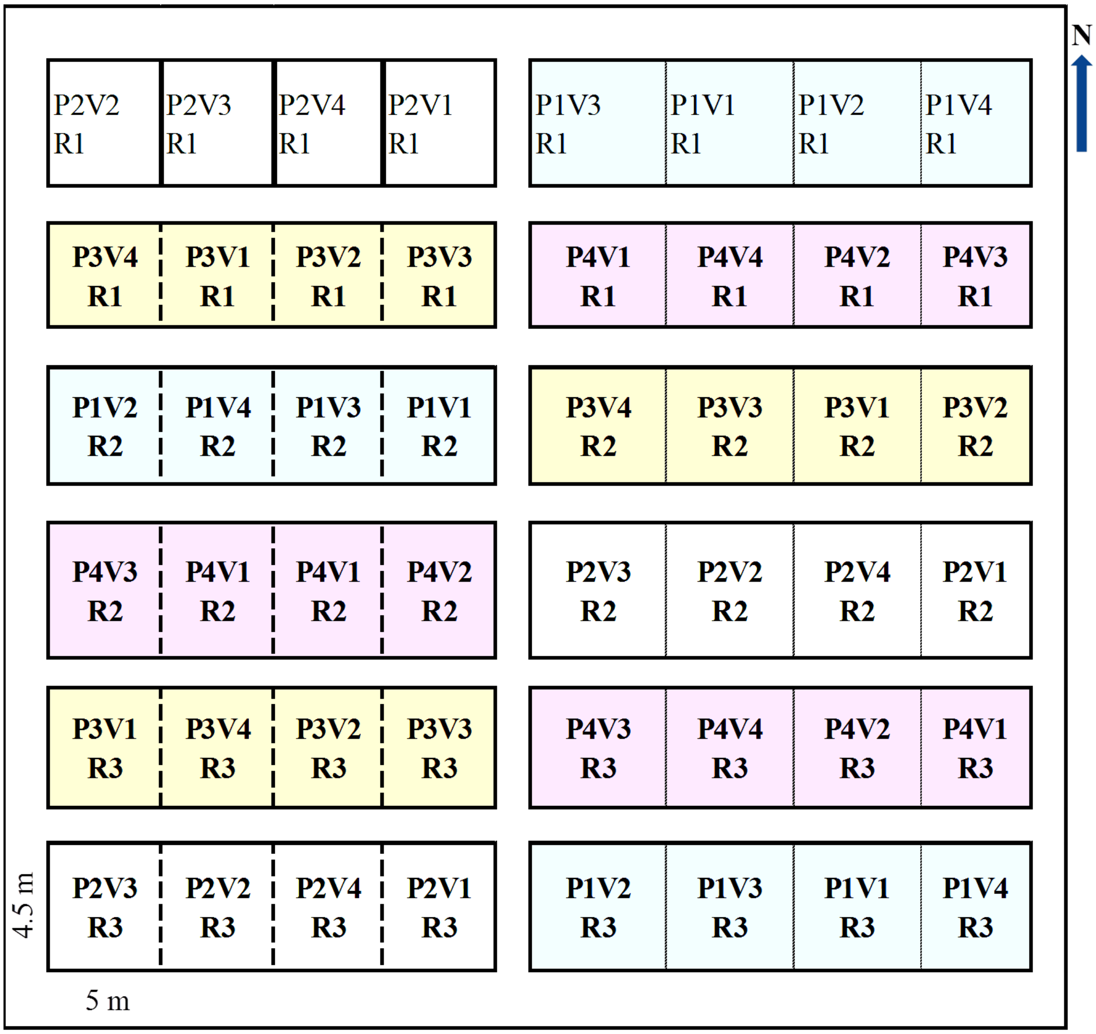
WESTGATE., M.E. (1997). Physiology of flowering in maize: Identifying a venues to improve kernel set during drought. Proceedings of a Symposium, March 25-29, 1996. CIMMYT, El Batam, Mexico. Pp 136-141.

WESTGATE, M.E., M.E. OTEGUI, and F.H. ANDRADE, (2004).Physiology of the corn plant, p. 235-273 In C.W. Smith, J. Betrán, and E.C.A Runge. (eds.) Corn: Origin, History, Technology, and Production. John Wiley & Sons, Inc., Hoboken, N.J.

WIATRAK, P.J, D.L.WRIGHT, J.J.MARIOS and R.SPRENKE, (2004). Corn hybrids for late planting in the southeast U.S.A.agronomy Journal.96:1118-1124.

YOKOZAWA, M. & HARA, T. (1995). Foliage profile, size structure and stem diameter-plant height relationship in crowded corn plant population. Ann Bot. 76, 271-285.

APPENDIX



P2V2 R1	P2V3 R1	P2V4 R1	P2V1 R1	P1V3 R1	P1V1 R1	P1V2 R1	P1V4 R1
P3V4 R1	P3V1 R1	P3V2 R1	P3V3 R1	P4V1 R1	P4V4 R1	P4V2 R1	P4V3 R1
P1V2 R2	P1V4 R2	P1V3 R2	P1V1 R2	P3V4 R2	P3V3 R2	P3V1 R2	P3V2 R2
P4V3 R2	P4V1 R2	P4V1 R2	P4V2 R2	P2V3 R2	P2V2 R2	P2V4 R2	P2V1 R2
P3V1 R3	P3V4 R3	P3V2 R3	P3V3 R3	P4V3 R3	P4V4 R3	P4V2 R3	P4V1 R3
P2V3 R3	P2V2 R3	P2V4 R3	P2V1 R3	P1V2 R3	P1V3 R3	P1V1 R3	P1V4 R3

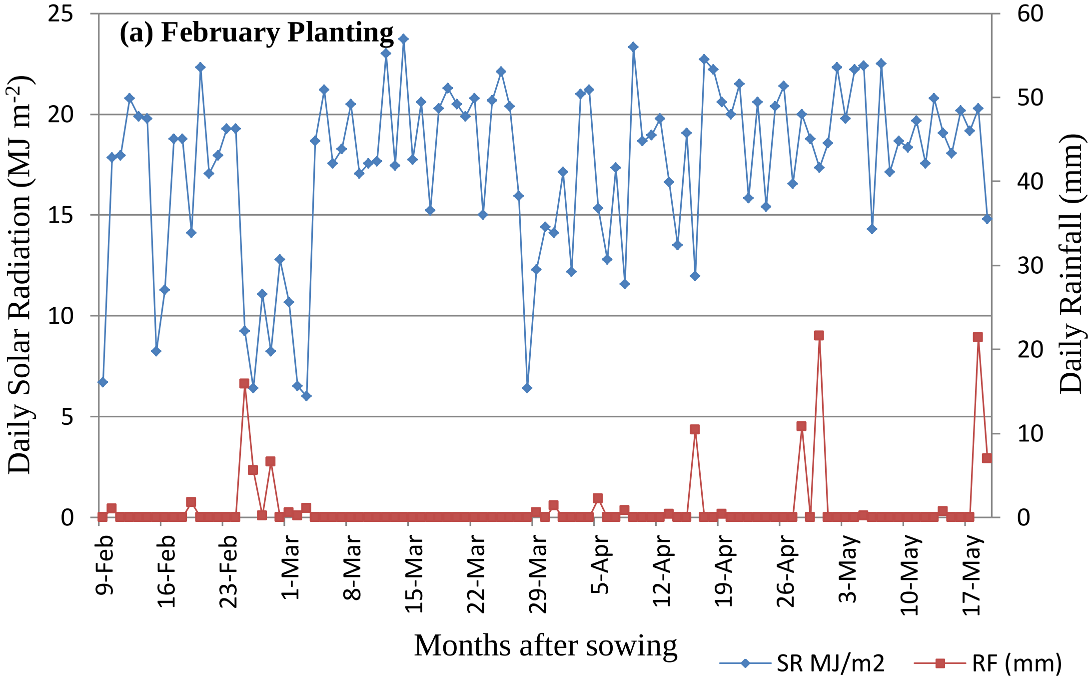
Figure 1 Layout of the experiment (RCBD design).

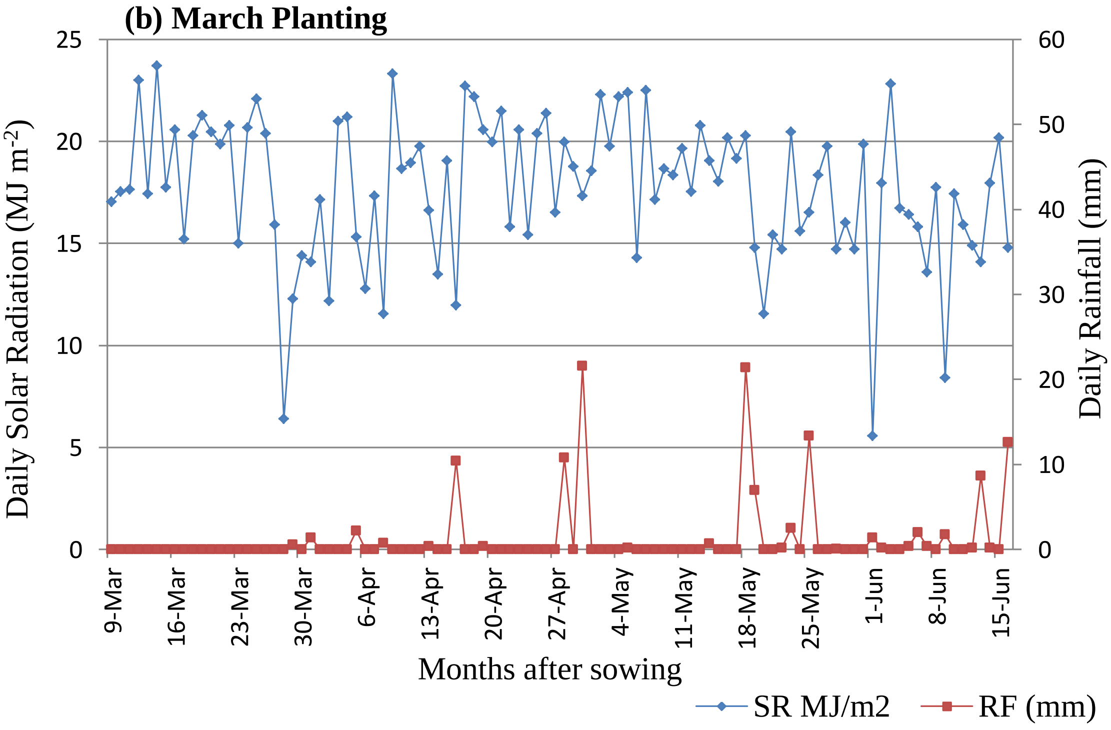
V1 = Supersweet P1 = 9th February

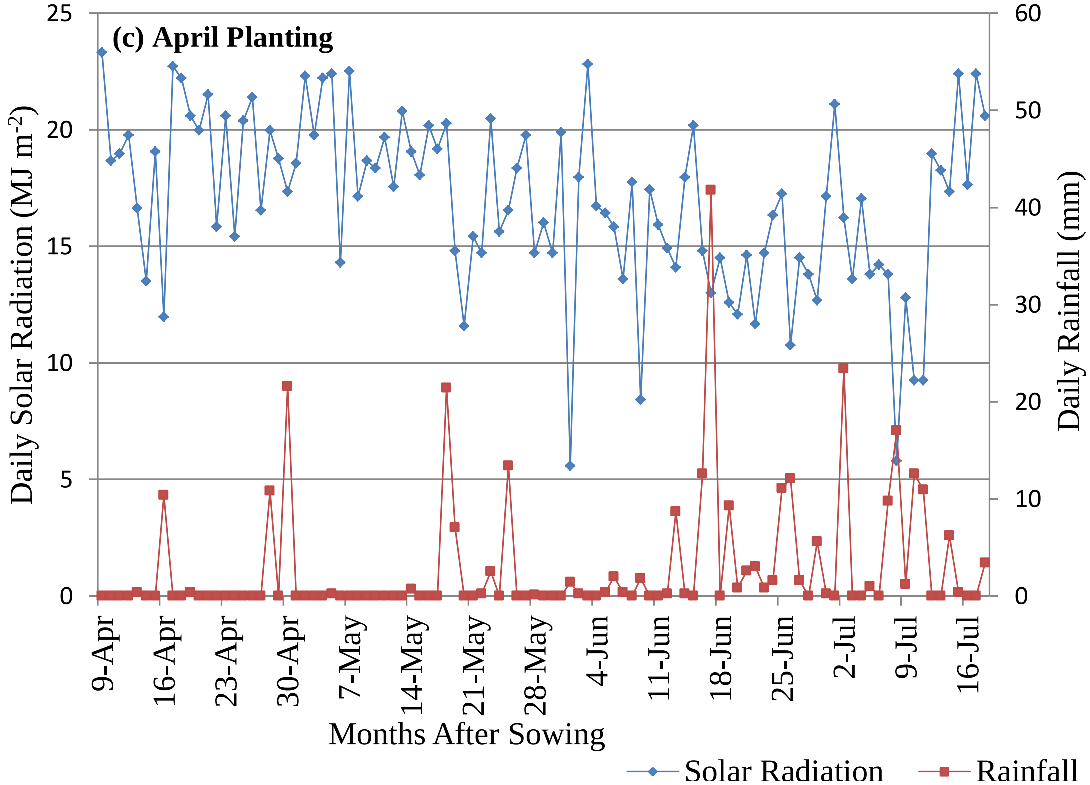
V2 =IES Glutinous-4 P2 = 9th March

V3 = MMSU P3 = 9th April

V4 = Sweet Jubilee-209 P4 = 9th May


(a) February Planting
Daily Solar Radiation (MJ m^{-2})
Daily Rainfall (mm)
0
5
10
15
20
25
0
10
20
30
40
50
60
9-Feb
16-Feb
23-Feb
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
17-May
Months after sowing
SR MJ/m2
RF (mm)


(b) March Planting
Daily Solar Radiation (MJ m^{-2})
Daily Rainfall (mm)
0
5
10
15
20
25
0
10
20
30
40
50
60
9-Mar
16-Mar
23-Mar
30-Mar
6-Apr
13-Apr
20-Apr
27-Apr
4-May
11-May
18-May
25-May
1-Jun
8-Jun
15-Jun
Months after sowing
SR MJ/m2
RF (mm)


(c) April Planting
Daily Solar Radiation (MJ m^{-2})
Daily Rainfall (mm)
25
20
15
10
5
0
60
50
40
30
20
10
0
9-Apr
16-Apr
23-Apr
30-Apr
7-May
14-May
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
Months After Sowing
Solar Radiation
Rainfall

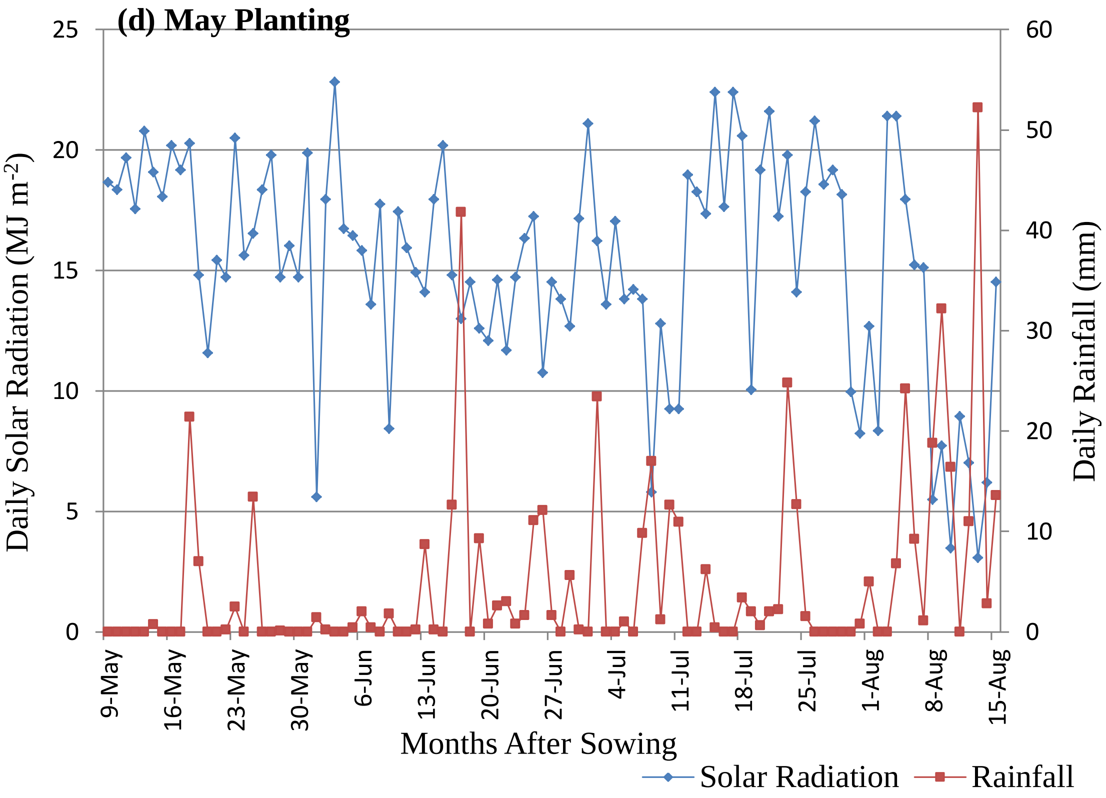


Figure 2 Daily solar radiation, and rainfall during crop cycle within (a) February planting, (b) March planting, (c) April planting and (d) May planting under Los Baños condition, 2016.

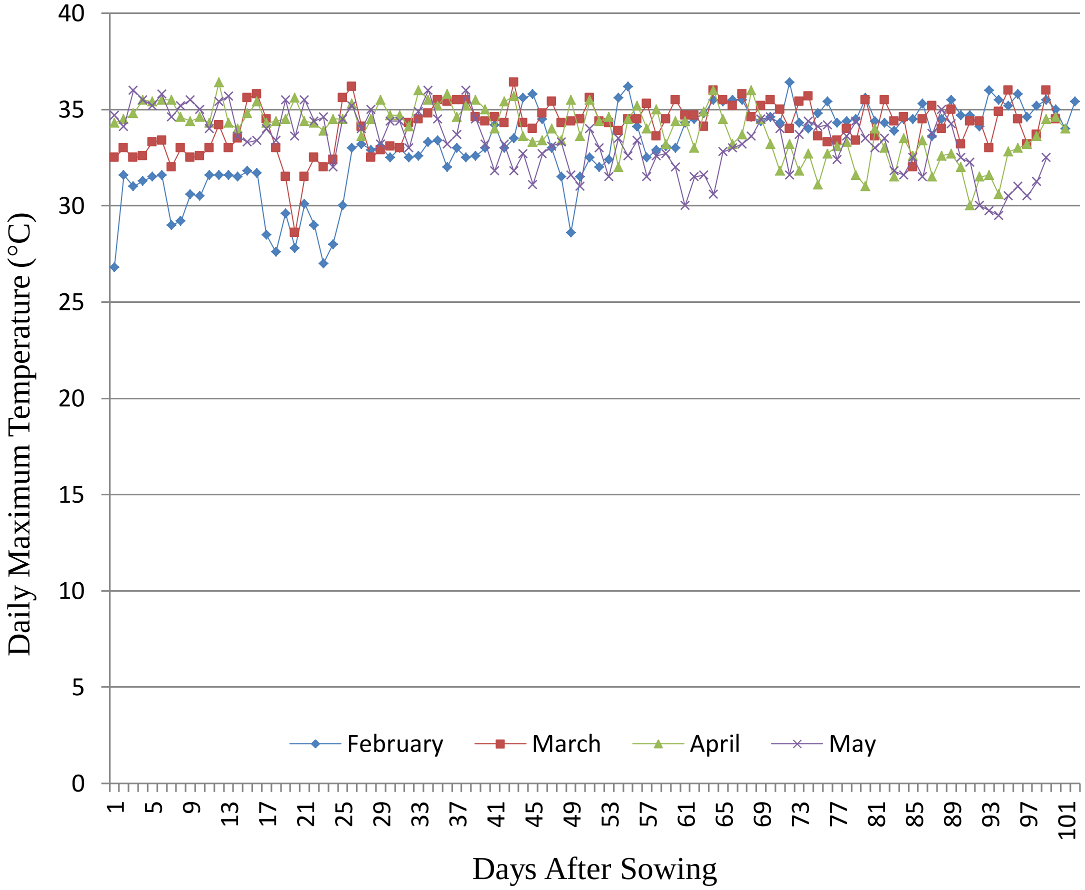


Figure 3 Daily maximum temperature during crop cycle within each planting time (February-May) under Los Baños condition, 2016

Table 1 PR>F-values from the analysis of variance for days to 50 % V6, days to 50 % tasseling, days to 50 % silking (R1) and days to 80% physiological maturity (R6) of four maize cultivars under four planting times.

TREATMENT	Pr >F			
	Days to 50% V6	**Days to 50% Tasseling**	**Days to 50% silking**	**Days to 50% physiological maturity**
Planting Time (PT)	0.0000	0.0001	0.0014	0.0000
Cultivar (C)	0.0014	0.0000	0.0000	0.0000
PT*C	0.5527	0.3458	0.0465	0.0000
CV %	7.06	4.94	5.53	1.79

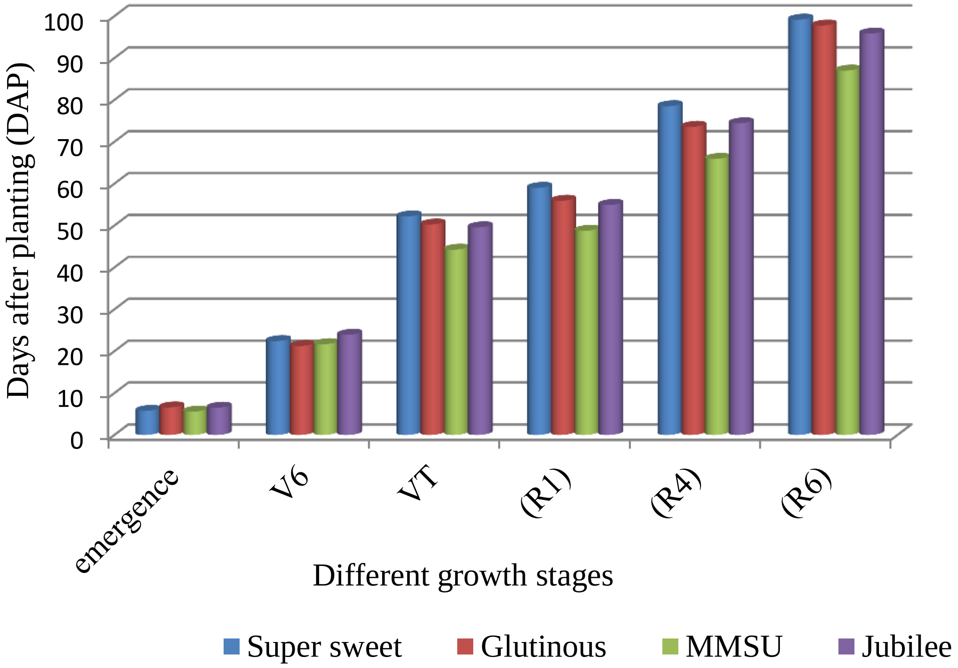


Figure 4 Days to different growth stages as affected by cultivars

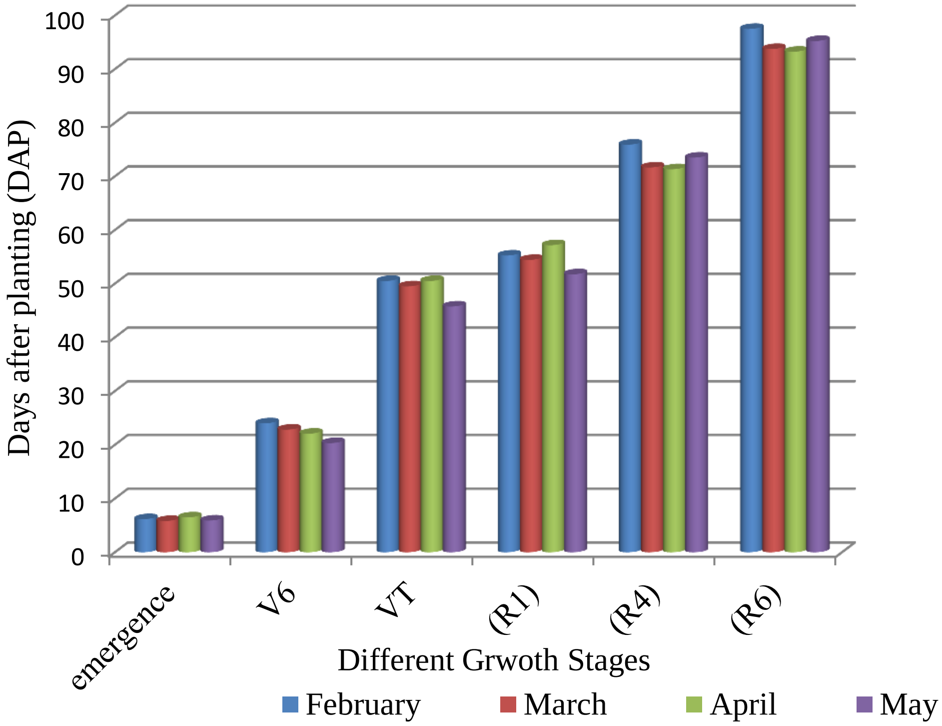


Figure 5 Days to different growth stages as affected by planting time.

Table 2 Pr> F values for number of leaves (NL), plant height (PH), leaf area index (LAI), total dry matter at harvest (TDM) and harvest index (HI) in maize cultivars as affected by planting time (February- May) under Los Baños condition, 2016

TREATMENT	**Pr > F**				
	NL	**PH**	**LAI**	**TDM**	**HI**
Planting time (PT)	0.0003	0.0000	0.0005	0.0000	0.0002
Cultivar (C)	0.0000	0.0003	0.0908	0.0000	0.0000
PT*C	0.7265	0.8655	0.8196	0.0637	0.3272
CV %	3.65	9.65	25.02	19.05	16.78

Table 3 . PR>F-values from the analysis of variance for crop growth rate (CGR) of four maize cultivars at different growth stages as affected by planting time under LosBaños condition. 2016.

GROWTH STAGE	**Pr> F**				
	Planting time (PT)	**Cultivar (C)**	**C*PT**	**CV%**	**Mean**
V6 (six- leaf)	0.0069	0.0628	0.6550	33.96	0.801
R1 (silking)	0.0000	0.8123	0.1955	25.07	13.51
R4 (dough)	0.1150	0.0007	0.4843	45.02	16.08
R6 (maturity)	0.6929	0.0664	0.2140	71.62	5.78

Table 4 PR>F-values from the analysis of variance Summary of ANOVA for number of ears per m^2 (NE), number of kernels per m ^{2} (NK), kernel weight per m ^{2} (KW), thousand kernel weight (TKW) and grain yield (GY) in maize cultivars as affected by planting time (February- May) under Los Baños condition, 2016.

TREATMENT	**YIELD COMPONENT PARAMETER**				
	NE (Ears per m$^{2)}$	**NK (kernels per m^2)**	**KW (g per m^2)**	**TKW (g)**	**GY (kg/ha)**
Planting Date (PD)	0.5405	0.0022	0.0000	0.3270	0.0610
Cultivar (C)	0.0106	0.9945	0.0000	0.0000	0.0000
PD*C	0.5438	0.9231	0.5407	0.7953	0.2060
CV %	12.25	32.24	24.82	12.10	18.85