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Managing the Biotic and a Biotic Stress by Introduction of Genetically Modified Organism (GMO) Corn in Philippines—A Successful Story

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Abstract

Genetically modified yellow corn help increase the productivity of the Filipino farmers since 2002. The yellow corn industry occupied 0.93 million hectares in 2000 and 1.4 million hectares in 2020. The country produced 4.5 million tons in 2000 and 8 million tons in 2020 with the average yield of per hectare of 1.8mt and 3.18mt, respectively. Specially in yellow corn production, GM corn gave significant impact from the yield of 2.8mt/ha in the year 2000 increases up to 4.18 mt/ha in 2020 with occupying almost 800 thousand hectares. In the past 18 years and onwards, Filipino corn farmers continue benefiting the advantage of the technology and addressed most of the biotic and abiotic stresses in the corn production and improved farming system.

Key words : *GMO, corn, biotic and abiotic stress, farming system, productivity.*

Introduction

Corn is third most important crop in the Philippines in terms of area harvested and economic value. The country produced 4.5 million tons 2000 and 8 million tons in 2020 with the average yield of per hectare of 1.8mt and 3.18mt, respectively occupied 2.5 million hectares.

Wet tropical growing condition imposes unlimited biotic and a-biotic stresses on corn plant and productivity improvement is always a challenge through conventional breeding methods. Effort on the commercial breeding started way back in 1970 when pioneer international has started developing yellow corn hybrids to help improved productivity of Filipino farmers. That time, it was a challenge to introduce the yellow corn, as white corn was the most preferred grain for eating.

Philippines has emerged as one of the very strong breeding sites for developing corn germplasm with good tolerance to both Biotic and Abiotic stresses across the world. Over the period, Biotic and Abiotic greatly affects corn productivity. Continues planting corn after corn has increase the insect pressure which has become the major yield reducing factor. The Corn borer is considered as the most destructive pest of maize in the Philippines with the yield loss of 30-100%. Other significant pests are Corn earworm, Cutworm and recently Fall Army worm that was first reported in June 2019 Piat, Cagayan Province causing billions of damages in corn. Weeds also noted a substantial problem including soil fertility due to lack of soil nutrient management. Flood during wet season and drought during dry season considered additional hurdle to the corn farmers. Wet climatic condition also causes the major concern for weed management which does not only cause the yield losses but also create inconvenience for the farming system. These two big problems have built the stress on corn farming system and conventional breeding technique was unable to provide the perfect solutions.

In December 2002, Philippines became the first country in Asia to approve GM crop namely, Bt corn for commercial cultivation for food and feed. Bt yellow corn was the first introduce as GM, since last 19 years Filipino farmers are enjoying the benefit of the technology and increase significantly the yield productivity from 2.80mt in 2000 to 4.18mt in 2020 which gave 49.2 % increase. Vietnam is another country which has seen the significant benefit of the GMO technology in Philippines and approved for commercial use in 2010.

Philippines considered as good example and evidence which can be use by other Asian countries and make the use of technology for improving the corn productivity and making corn farming system more profitable. This made possible because of the Philippines biosafety regulation existed as early as 1990 Executive Order 430, due to the proactiveness of the scientists who crafted the regulation. Infrastructure for biotechnology existed as early as 1979. The importance of plant biotechnology was recognized in Republic Act No. 7308-1992. By the time that the private sector applied for biosafety evaluation, the regulatory committee was ready to conduct a science-based biosafety evaluation.

This article we are trying to highlight the importance of the GMO technology that create nature friendly, convenient and profitable farming system.

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Climate : The Philippines has five types of climates : tropical rainforest, tropical monsoon, tropical savanna, humid subtropical and oceanic (both are in higher-altitude areas) characterized by relatively high temperature, oppressive humidity and plenty of rainfall. There are two seasons in the country, the wet season and the dry season, based upon the amount of rainfall.(1) This is also dependent on location in the country as some areas experience rain all throughout the year (see Climate types). Based on temperature, the warmest months of the year are March through October; the winter monsoon brings cooler air from November to February. May is the warmest month, and January, the coolest.

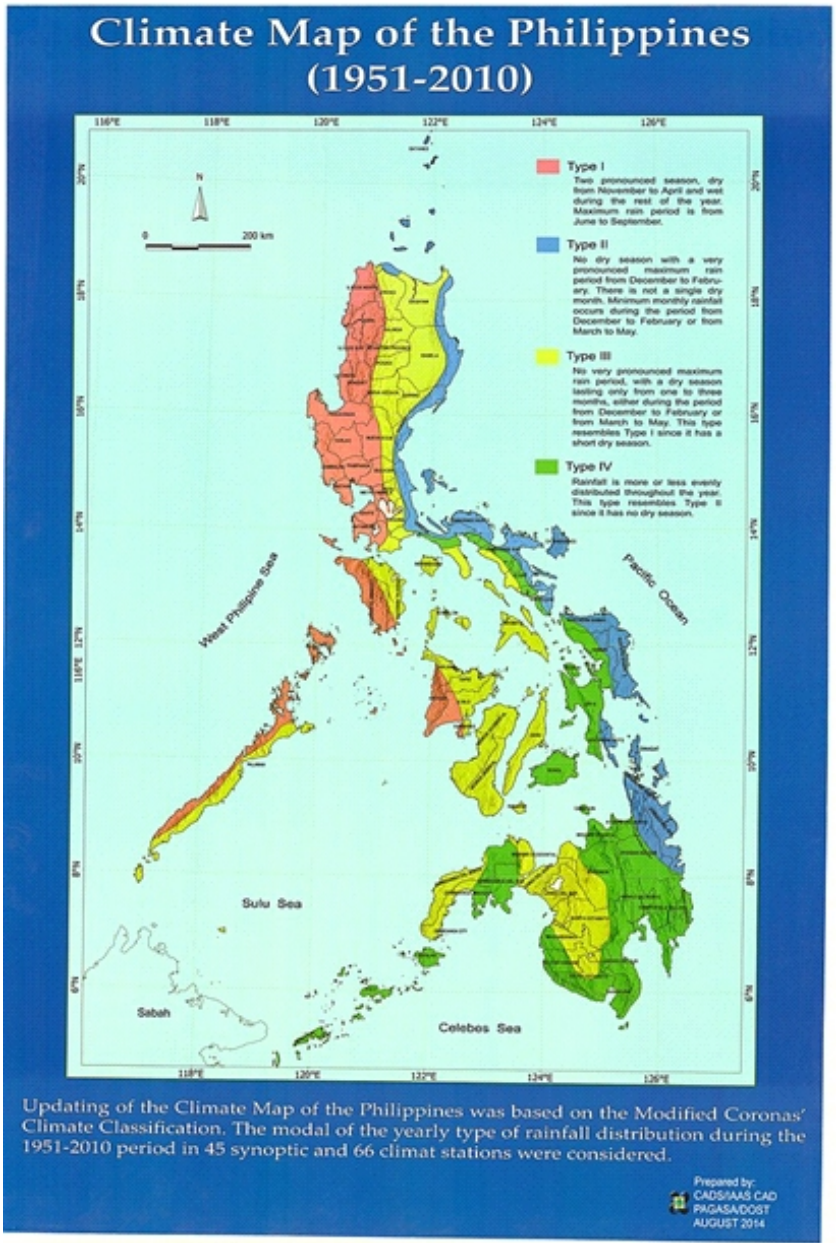
There are four recognized climate types in the Philippines, and they are based on the distribution of rainfall. They are described as follows :

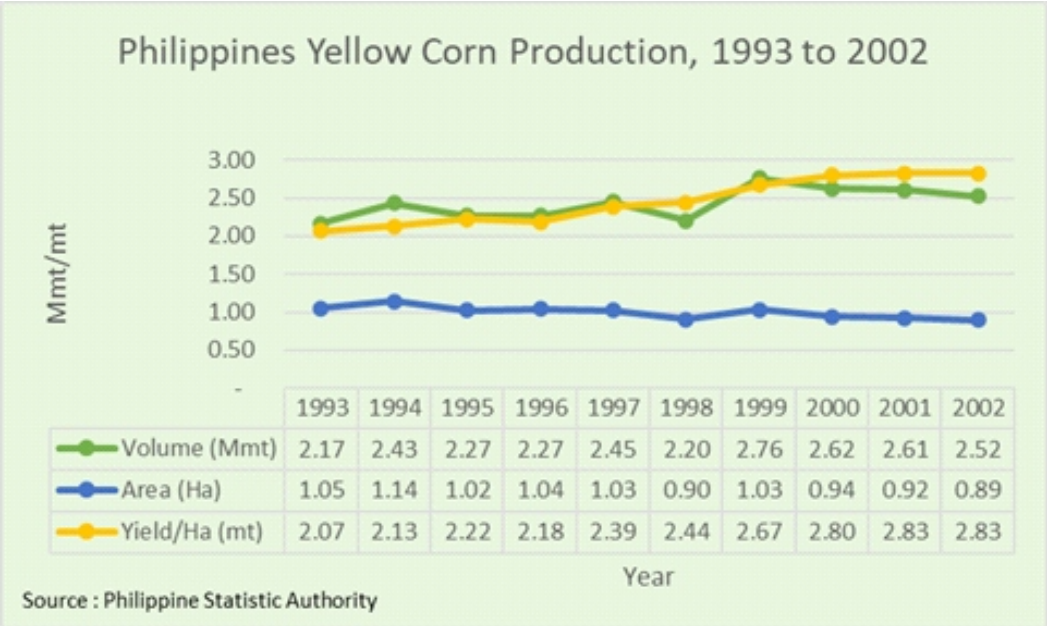
Type I Two pronounced seasons: dry from November to April and wet during the rest of the year. Maximum rain period is from June to September.

Type II No dry season with a very pronounced maximum rain period from December to February. There is not a single dry month. Minimum monthly rainfall occurs during the period from March to May.

Type III No very pronounced maximum rain period, with a short dry season lasting only from one to three months, either during the period from December to February or from March to May. This climate type resembles type I since it has a short dry season.

Type IV Rainfall is more or less evenly distributed throughout the year. This climate type resembles the second type more closely since it has no dry season.





	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Volume (Mmt)	2.17	2.43	2.27	2.27	2.45	2.20	2.76	2.62	2.61	2.52
Area (Ha)	1.05	1.14	1.02	1.04	1.03	0.90	1.03	0.94	0.92	0.89
Yield/Ha (mt)	2.07	2.13	2.22	2.18	2.39	2.44	2.67	2.80	2.83	2.83

Also, below climate map of the Philippines based on the modified Corona's Climate Classification based on the type of rainfall distribution in 1951-2010.

Climate change is one of the major issues nowadays because of the threat it poses to environment and on biological existence. Agricultural crop production system is very sensitive to changes in weather and to seasonal, annual and long-term variation in climate. Crop growth and development as well as different physiological processes are highly influenced by climate. On the contrary, occurrence of pest and different crop diseases are also attributed to climate. Land preparation, date of sowing, irrigation, fertilization, harvesting, and other farms activities are also affected by climate. Climate change is expected to affect crop yield, total volume of production and the spatial distribution or location of the major crop production regions.

Corn considered as the 2nd important cereal crops in the country, also among the field crops that directly hit by the climate change. The impact of climate change on corn will not only affect it production system but also the different social and economic activities.

Philippine corn production prior GM introduction : Among the world three major staple crops: Corn, rice and wheat. Corn (yellow and white) contribute the most in terms of human intake viz 19.5, 16.5 and 15 percent respectively. Corn classified depending on the nature of the grain, *i.e*, whether hard (flint), sticky (glutinous), or sweet. All of these can be yellow, white, or the rare other colors (red, purple, brown, blue and combinations. Yellow flint is preferred for feeds because of high carotene content and is very important in poultry, especially egg-laying type (layers). For hogs, corn can be substituted by feed wheat and cassava.

In Philippines, white flint corn is consumed mostly in mountainous areas in Visayas and Mindanao. According to PSA (2015), the per capita consumption/year for corn in 2006 was only 14 kg, which later increased to 22 kg in 2014. While yellow corn is the primarily source for feed for animal industry and is increasingly used by the manufacturing sector unlike other countries such as Mexico, where yellow corn is used for food. Maize is commonly grown in upland areas and in rainfed lowlands (Gerpacio *et al.,* 2004).

The demand for and productivity of white corn as food is relatively flat. In contrast, both the demand and the productivity of yellow corn are generally growing due to our increasing demand for meat.

Even as corn production has been increasing over the past years, there are major issues that affect productivity.

Biotic and Abiotic stresses : The Asian Corn Borer (*Ostrinia furnacalis* Guenee), is considered the most destructive pest which bores into the ear, attacks tassel, and damage parts of the plants, lowering the yields. Farmers must spray pesticides to control the outbreak which increased the cost and exposed farmers to health risk. It is estimated that yield loss of 30-100%. Other significant pests are corn earworm (*Helicoverpa armigera* Hubn.), Cutworm and white grubs (*Leucopholis irrorata* Chev.). Weeds were also reported as a substantial problem, they also reduce productivity, likewise farmers spray herbicides continuously or deploy labor force to control the problem. As well as loss of soil fertility due to

GM Corn Approved for Propagation in the Philippines, as of July 27, 2021.

Direct Use of as Food and Feed, or for Processing	
Single Event	**Stacked transformation eventgs**
Corn MON88017	Corn BT11 DAS-59122-7 MIR604 TC1507 GA21 and all its intermediates
Corn MON810	Corn MON88017 MON810
Corn MIR604	Corn 3272 BT11 MIR604 TC1507 5307 GA21 and all its intermediates
Corn DAS59122-7	Corn MOB810 NK603
Corn 3272	Corn MON89034 NK603
Corn MZHG0JG	Corn NK603 T25
Corn MON87411	Corn MON87427 MON89034 MIR162 NK603 and all its intermediates
Corn TC1507	Corn TC1507 Corn DAS59122 Corn MON810 Corn MIR604 Corn NK603 and all its intermediates
Corn DAS 40278-9	Corn Bt11 MIR162 MIR604 MON89034 5307 GA21 and its intermediates
NK603	Corn Bt11 MIR162 MIR604 TC1507 5307 GA21 and its intermediates
Corn MON87419	Corn TC1507 MON810 MIR162 NK603 and all its intermediates
Corn T25	Corn MON89034 TC1507 NK603 and all its intermediates
Corn BT11	Corn GA221 T25
Corn MZIR098	Corn GA21 T25
Corn MON89034	Corn MON87427 MON89034 TC1507 MON88017 DAS-59122-7
Corn MON89304	
Corn GA21	
Corn 5307	
For Propagation/Planting	
Single Event	**Stacked transformation events**
Corn MON810	Corn MON89034 Corn NK603
Corn MIR162	Corn TC1507 Corn MON810 Corn NK603 and all its intermediates
Corn TC1507	Corn Bt11 MIR162 MON89034 GA21 and all its intermediates
Corn GA21	Corn MON89034 TC1507 NK603 and all its intermediates
Corn Bt11	Corn Bt11 TC1507 GA21 and all its intermediates
Corn NK603	
Corn MON89034	

soil erosion and lack of proper nutrient management aggravate the problem. Flooding during wet season and/or drought during dry season are also contributes.

Fig.-1 : ACB pictures.

Input Supply Constraints : In general, the cost of inputs is a major concern to corn farmers, as is the timely availability of inputs. Lack of farm labor, especially during peak periods of land preparation, planting, and harvesting were also identified as constraints.

GM Introduction in the Philippines : Corn Production is affected by several factors, Biotechnology is a possible solution to address these factors. *Bacillus thuringiensis* (Bt) corn is the first generation of GM in the Philippines. It was introduced by the multi-National companies in 2002 following the issuance by the Department of Agriculture of its regulation on commercial propagation and importation of plant and plant products.

Bt corn was first introduced in commercial scale in 2003, Insect Resistant corn developed to address major pests (ACB) and reduce the use insecticides. Bt is a natural enemy of the corn borer, which gets killed upon ingesting the microbe. Bt corn has a foreign Bt gene inserted into its genome using microparticle bombardment of plant cells or agrobacterium tumefaciens-mediated plant transformation. The inserted Bt gene enables the plant to protect itself from corn borers increasing yields. Without need to spray pesticide against ACB, the acquired trait gives GM corn farmers higher profits.

Following the Bt corn event, another GM corn product was developed the herbicide tolerance corn, carrying an external gene enabling the plant to express what is essentially effective tolerance against weedicides and other herbicides. Which help reduce labor weed management, consequently reducing production cost.

Subsequent improvements of genetic engineering in corn produced the GM corn with stacked events that combined both the insect-resistant and herbicide-tolerant capabilities of the corn plant.

The latest problem of the country industry in 2019, was detection of Fall Army worm (*Spodoptera frugiperda*, FAW) last June 20, 2019 in Pait Cagayan, Philippines. Morphological examination was done and matched with the distinctive characters for S. frugiperda. Subsequent collections from other corn growing areas in Cagayan and Ilocos Norte yielded additional specimens for validation using molecular markers.

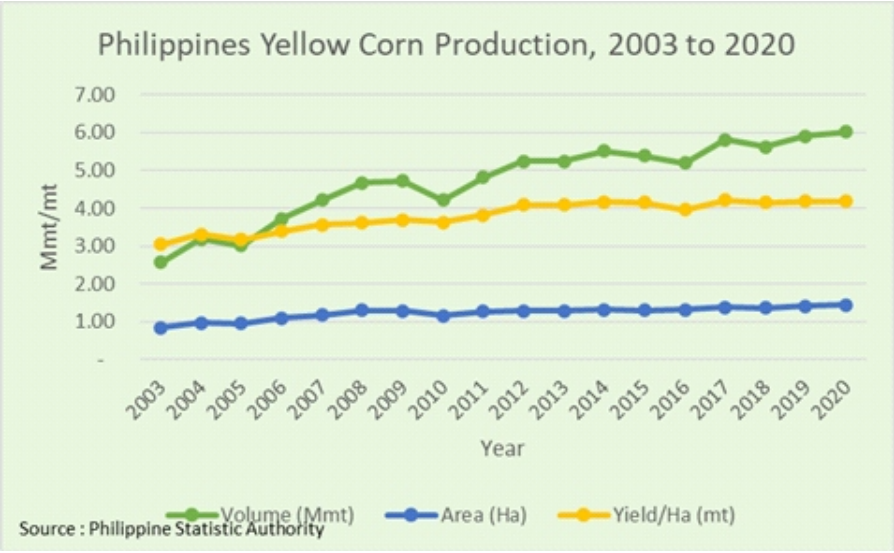
The National Crop Protection Center (NCPC) and Institute of Weed Science, Entomology and Plant Pathology (IWEP), College of Agriculture and Food Science, University of the Philippines Los Baños verified the identity of the specimens using the DNA barcode cytochrome c oxidase 1 (COI) gene and results revealed a significant hit of 100% identity with nucleotide sequences of *S. frugiperda*.

Government and agricultural companies are coordinating and monitoring the spread of this pest before it affects the nation's production. Established protocols and guidelines on how to control this pest. FAW has become a major pest in the country reduces grain harvest and quality, estimated to bring potential damage between 60% to 80% if corn crops are not managed properly during infestation.

With the approved GM corn hybrid having dual effective mode of action that have proven built-in resistance against fall armyworm lessen the impact of FAW in the country. This GM corn has a maximum protection against fall armyworm, corn borer, corn earworm, and other above-ground pests notorious for wreaking havoc on corn crops leading to huge yield losses.

Farmers who planted FAW-resistant varieties witnessed the clear advantage of using this technology and eliminate the need for manual control.

Upon the introduction of GM, corn productivity in the country increased significantly particularly in yellow corn both production area and volume. In 2000 yellow corn



produced 2.52 million metric tons (Mmt) from 0.89 million hectares with the average yield per hectare of 2.8 mt/ha and in 2020, 6.01 Mmt was produced from 1.44 million hectares with the average yield per hectare of 4.18 mt/ha. Below the data showing the significant impact of GM corn in corn industry from 2003 year of introduction to 2020 and Bt adoption continuously increasing to about 835 thousand hectares in 2019 covering 59% of total yellow area in the country.

In the past 18 years, the Filipino corn farmers continue benefiting the advantage of the technology and addressed most of the biotic and abiotic stresses in the corn production and improved farming system.

References

1. Alvarez F., Manalo A. and Clarete R. (2019). Economic Assessment of GM Corn Use in the Philippines. Retrieved September 12, 2021 from *International Journal of Food Science and Agriculture*, 2021, 5(1): 115-128. Hill Publishing Group (hillpublisher.com).
2. APAARI (2019). GM Maize in the Philippines–A Success Story. *Asia-Pacific Association of Agricultural Research Institutions,* Bangkok, Thailand. xx+79 p.
3. Biotechnology Philippines (2020). IRM Monitoring. http://biotech.da.gov.ph/Irm.php. [12] Philippine Statistic Authority. (2020). Palay and Corn: Area Harvested by Ecosystem/Croptype, by Quarter, by Semester, by Region and by Province, 1987-2020 by Ecosystem/ Croptype, Geolocation, Year and Period. https://openstat.psa.gov.
4. Bureau of Plant Industry (2019). Report on first detection of Fall Army Worm (FAW) in the Republic of the Philippines. Retrieved September 19, 2021 from https://reliefweb.int/report/philippines/report-first-detection-fall-army-worm-faw-republic-philippines.
5. Carlo C. (2019). GM Maize in the Philippines–A Success Story. Retrieved September 10, 2020 from www.apaari.org; www.apcoab.org.
6. Conrow J. (2021). Filipino-farmers-reap-economic- benefits-from-gmo-corn-study-finds. Retrieved September 12, 2021 from https://alliance for science. cornell. edu/blog/2021/07/filipino-farmers-reap-economic-benefits-from-gmo-corn-study-finds/.
7. Gerpacio R.V., J.D. Labios R.V. Labios and E.I. Diangkinay (2004). Maize in the Philippines: Production Systems, Constraints, and Research Priorities. Mexico, D.F.: CIMMYT.
8. Conrow J. (2015). Climate change Impact on Corn Productivity in the Philippines. *International Journal of Sciences : Basic and Applied Research (IJSBAR)*. 23(1): 54-68.
9. Philippine Atmospheric, Geophysical and Astronomical Services Administration. Archived from the original on November 15, 2015. Retrieved November 26, 2015.
10. Philippine Statistic Authority. (2020). Palay and Corn: Volume of Production by Ecosystem/Croptype, by Quarter, by Semester, by Region and by Province, 1987-2020 by Ecosystem/Croptype, Geolocation, Year and Period. https://openstat. psa.gov.ph