



**UNIVERSITI PUTRA MALAYSIA**

**USE OF ORGANIC FERTILIZER AND BIOFERTILIZER ON CORN-  
SOYBEAN INTERCROPPING FOR SILAGE PRODUCTION**

**NOORHANIN BINTI DZULKFLI**

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SOYBEAN INTERCROPPING FOR SILAGE PRODUCTION**

By

**NOORHANIN BINTI DZULKFLI**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in  
Fulfilment of the requirements for the Degree of Master of Science**

**August 2017**

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*Specially dedicated to:*

*My late father Dzulkfli Hamzah*



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree Master of Science

## USE OF ORGANIC FERTILIZER AND BIOFERTILIZER ON CORN-SOYBEAN INTERCROPPING FOR SILAGE PRODUCTION

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August 2017

**Chairman : Assoc. Prof. Mohd Ridzwan Abd Halim, PhD**  
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Continuous usage of chemical fertilizers contributes to environmental pollution. This awareness leads society to find alternative fertilizers like organic fertilizers and biofertilizers. In this regard, an experiment was conducted at Universiti Putra Malaysia in two seasons to determine the effects of different fertilizer on growth and yield of corn intercropped with soybean and nutritive quality of mixed forage and silage. Six fertilizer treatments with three replications were arranged in randomized complete block design. The treatments were 100% chemical fertilizer (NPK), 100% poultry manure (PM), 50% PM, combined application of 50% PM with biofertilizer, sole biofertilizer and untreated (control). The results showed that highest yield of corn and soybean was obtained from 100% NPK but in the second season, 100% PM produced similar yield with 100% NPK. Sole biofertilizer was capable of producing equal yield as 50% PM. However, the combined application of 50% PM with biofertilizer did not increase the yield to the same level as either 100% PM or 100% NPK in both seasons. In terms of forage quality, 100% PM and 100% NPK produced the highest crude protein (CP) content (14.57% and 14.31% respectively) but only 100% PM gave desirable values for neutral detergent fiber (NDF) (49.86%) and acid detergent fiber (ADF) (27.77%) compared to others. Nutritive quality of the corn-soybean silage reflected the original material properties before storage where 100% PM produced high value of CP with lowest values of NDF and ADF. Dry matter, pH and volatile fatty acids of silage were not significantly affected by fertilizer treatments. Another objective was to quantify the biological nitrogen fixation (BNF) by soybean intercropped with corn. Corn and soybean root samples were harvested at 30 days after planting and were prepared for acetylene reduction assay (ARA). The ARA result may reflect nitrogenase activity because nitrogenase responsible in reduction of molecular dinitrogen ( $N_2$ ) to ammonia ( $NH_4^+$ ) and also in reduction of acetylene to ethylene. The results showed that high ARA rates for corn ( $12.73 \text{ nmol h}^{-1}$ ) and soybean ( $41.45 \text{ nmol h}^{-1}$ ) were obtained from treatments containing biofertilizer. Control plots also gave high ARA rate above 100% NPK, 100% PM and 50% PM. This indicates that BNF is increase in low nitrogen level condition and inhibited by high nitrogen level.

Biofertilizer treatments did not improve the yield and quality of mixed forage and silage over 100% NPK or 100% PM. Therefore, 100% poultry manure at the rate of 6.3 t ha<sup>-1</sup> which equivalent to 140 kg N ha<sup>-1</sup> is recommended to produce high yield and quality of mixed forage and silage.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

## PENGGUNAAN BAJA ORGANIK DAN BAJA BIO DALAM PENANAMAN SELINGAN JAGUNG-SOYA UNTUK PENGELUARAN SILAJ

Oleh

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**Pengerusi : Prof. Madya Mohd Ridzwan Abd Halim, PhD**  
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Penggunaan baja kimia secara berterusan telah menyumbang kepada pelbagai pencemaran alam. Kesedaran mengenai hal ini telah menyebabkan masyarakat untuk mendapatkan baja alternatif seperti baja organik dan baja bio bagi menggantikan baja kimia. Justeru, eksperimen telah dijalankan sebanyak dua musim di Universiti Putra Malaysia untuk menilai potensi baja organik dan baja bio bagi pengeluaran silaj. Eksperimen pertama dilaksanakan untuk menentukan kesan baja ke atas pertumbuhan dan hasil penanaman selingan jagung dan soya dan ke atas kualiti nutrisi foraj campuran dan silaj. Enam rawatan baja dengan tiga replikasi di susun secara reka bentuk blok lengkap terawak. Rawatan baja tersebut ialah 100% NPK, 100% tahi ayam (PM), 50% PM, kombinasi aplikasi 50% PM dengan baja bio, baja bio tunggal dan tiada pembajaan (kawalan). Keputusan menunjukkan hasil tertinggi bagi jagung dan soya diperolehi dari 100% NPK namun pada musim kedua, 100% PM mengeluarkan hasil yang sama dengan 100% NPK. Baja bio tunggal berupaya mengeluarkan hasil yang sama seperti 50% PM. Walau bagaimanapun, kombinasi aplikasi 50% PM dengan baja bio tidak dapat meningkatkan hasil yang sama tahap dengan 100% PM mahupun 100% NPK. Bagi kualiti foraj, 100% PM dan 100% NPK menghasilkan kandungan protein kasar (CP) tertinggi (masing-masing dengan nilai 14.57% dan 14.31%) tetapi hanya 100% PM memberikan nilai rendah bagi neutral '*detergent fiber*' (NDF) (49.86%) dan asid '*detergent fiber*' (ADF) (27.77%) berbanding rawatan baja lain. Kualiti silaj jagung-soya mencerminkan sifat bahan asal sebelum penyimpanan iaitu 100% PM menghasilkan nilai CP yang tinggi beserta nilai paling rendah untuk NDF dan ADF. Berat kering, pH, dan asid lemak meruap bagi silaj tidak dipengaruhi oleh rawatan baja. Eksperimen kedua dijalankan bagi menentukan kadar pengikatan nitrogen secara biologi (BNF) oleh bacteria daripada baja bio. Sampel akar jagung dan soya diambil pada hari ke-30 selepas penanaman dan disediakan untuk prosedur penurunan asetilena (ARA) yang dijalankan di dalam makmal. Keputusan menunjukkan bagi kedua-dua musim, kadar ARA yang tinggi bagi jagung (12.73 nmol h<sup>-1</sup>) dan soya (41.45 nmol h<sup>-1</sup>) diperolehi daripada rawatan yang mempunyai baja bio. Petak kawalan juga memberikan kadar ARA yang tinggi melebihi rawatan 100% NPK, 100% PM dan 50% PM. Hal ini menunjukkan aktiviti BNF aktif dalam keadaan

kandungan tahap nitrogen rendah dan aktiviti ini terhalang oleh tahap kandungan nitrogen tinggi. Walaupun BNF membantu meninggikan kandungan nitrogen dalam tanah, ia tidak dapat meningkatkan hasil dan kualiti foraj campuran dan silaj melebihi hasil daripada 100% NPK atau 100% PM bagi eksperimen ini. Justeru, 100% PM dengan kadar  $6.3 \text{ t ha}^{-1}$  bersamaan  $140 \text{ kg N ha}^{-1}$  dicadangkan bagi mengeluarkan hasil dan kualiti foraj campuran dan silaj.





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I certify that a Thesis Examination Committee has met on to conduct the final examination of Noorhanin Binti Dzulkfli on her thesis entitled “Use of Organic Fertilizer and Biofertilizer on Corn-Soybean Intercropping System for Silage Production” in accordance with Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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## LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
ANOVA	Analysis of Variance
ARA	Acetylene Reduction Assay
BIO	Biofertilizer
BNF	Biological Nitrogen Fixation
cfu	Colony Forming Unit
CP	Crude Protein
cv	Coefficient of Variance
DM	Dry Matter
DMD	Dry Matter Digestibility
FID	Flame Ionization Detector
HSD	Honest Significant Different
ISR	Induced Systemic Resistance
LAI	Leaf Area Index
MOP	Muriate of Potash
NB	Nutrient Broth
NDF	Neutral Detergent Fiber
NIRS	Near Infrared Reflectance Spectroscopy
PGPB	Plant Growth Promoting Bacteria
PM	Poultry Manure
PSB	Phosphorus Solubilizing bacteria
RCBD	Randomized Completely Block Design
TSP	Triple Super Phosphate
VFA	Volatile Fatty Acids
WSC	Water Soluble Carbohydrates



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## CHAPTER 1

### INTRODUCTION

Corn (*Zea mays*) is the most widely planted crop in the world followed by wheat and rice. Worldwide corn production is 1037 million tonnes which is more than wheat (752 million tonnes) and rice (480 million tonnes) (Foreign Agricultural Services, 2017a). Corn is a versatile crop because each part of corn can be utilized and processed into various products. In Malaysia, corn is widely used for livestock feed. Every year, the demand for corn increases but the corn production in Malaysia cannot fulfill the market demand. Therefore, corn producers in Malaysia are encouraged to improve the yield and quality of corn including for silage production.

Corn as a whole plant is known to provide large amount of energy rich forage for ruminant diet but it has low protein content (74 to 95 g kg<sup>-1</sup>) (Reta Sánchez et al., 2010). The lack of protein content in corn forage can be overcome by intercropping corn with legumes such as soybean. Carter et al.(2004) reported that protein concentration of forage was greater under corn-soybean intercropping system compared to corn monoculture. Intercropping corn with soybean also increased component yield compared to corn monoculture (Keswani et al.,1977).Soybean can increase nitrogen intake by neighboring plants since it has the ability to fix nitrogen from the atmosphere (Li et al., 2001). Although intercropping system provides additional nutrients in the soil, fertilization is still needed to supply essential nutrients for plant growth and to ensure crop production reaches maximum level of profit.

Over the last 50 years, chemical fertilizers have been chosen as the source of nutrients for plant growth. However, application of chemical fertilizers is associated with increased risk of serious environmental problems including deterioration of soil fertility, destruction of the soil structure, pollution of groundwater, eutrophication, emission of nitrogen oxide and accumulation of toxic substances in crops (Savci, 2012). Nutrients in chemical fertilizers generally experience substantial losses due to drainage, leaching and runoff (Nsa et al., 2013).Chemical fertilizers provide nutrients in a ready-made form thus nutrients are released at a rapid rate. Plants also cannot absorb all the nutrients supplied by fertilizers because 20% of it will be lost to the atmosphere through volatilization while some will be fixed to organic compound in the clay particles. High concentration of nutrients may also increase the risk of damage to plant roots (Savci, 2012).

To overcome the negative effects of heavy use of chemical fertilizers, alternative methods of supplying nutrients to crops such as the use of organic fertilizers and biofertilizers should be promoted. So far, very little attention has been paid to the role of organic fertilizers and biofertilizers in the tropical region. Organic fertilizers have the potential to enrich total content of macronutrient and micronutrient and to improve soil condition.

Nutrients from organic fertilizers have a slower rate of release into the soil for plant uptake compared to chemical fertilizers which are highly water soluble (Adekiya and Agbede, 2016; Fu et al., 2012; Kihanda et al., 2006; Nsa et al., 2013). Despite the slower rate of nutrient release, the use of organic fertilizers has been shown to increase the growth and yield of corn (Wen et al., 2016), ginger (Soeparjono, 2016), tomato (Adekiya and Agbede, 2016) and herbs (Maboka et al., 2016).

Although organic fertilizers are rich in nitrogen, phosphorus and potassium elements, the proportions are normally unbalanced in relation to plant requirement. The lack of some nutrient elements in organic fertilizers can be addressed by using biofertilizers. Live microorganism in the biofertilizers may help to supply nutrients through nitrogen fixation, soil phosphorus solubilization and organic matter decomposition in the soil. Numerous soil microorganisms such as plant growth promoting rhizobacteria, phosphate solubilizing bacteria and mycorrhiza have been identified as beneficial microbes which help to increase yield of crops and build up long term soil productivity and fertility (Khan et al., 2009; Martin et al., 1991; Vessey, 2003).

Nitrogen-fixing bacteria contain nitrogenase enzyme that are responsible for catalyzing conversion of atmospheric nitrogen to ammonia. Symbiotically, the use of organic fertilizers may support the growth of nitrogen-fixing bacteria. Meanwhile biofertilizer consisting live microorganism may help the decomposition of organic matter provided by organic fertilizer. Therefore, both fertilizers contribute to the plant nutrition and intercropping corn with soybean also contributes nitrogen availability through nitrogen fixation, thus minimizing nitrogen loss to the environment.

The combined application of organic fertilizers and biofertilizers in corn-soybean intercropping system need to be studied as each type of fertilizer contain different components and supplies nutrients in different ways. The maximum yield potential can be achieved by optimizing the positive effects from both fertilizers.

Therefore, this study was conducted with the following objectives:

1. To determine the effects of organic fertilizer and biofertilizer on yield of mixed forage (corn-soybean) in corn-soybean intercropping system in comparison with chemical fertilizer.
2. To determine the effects of organic fertilizer and biofertilizer on nutritive quality of mixed forage and silage in comparison with chemical fertilizer.
3. To quantify the biological nitrogen fixation by soybean intercropped with corn.

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## BIODATA OF THE STUDENT

Noorhanin Dzulkfli was born in Penang, Malaysia on February 22, 1989. She obtained her primary education in 1997 and completed secondary education in 2006 at MARA Junior Science College. Next, she got an offer to study in Foundation Studies of Agricultural Science Program, Universiti Putra Malaysia (UPM) and continued for bachelor degree in Horticultural Science at Faculty of Agriculture, UPM. Before graduation, she did four months of internship in the Department of Agriculture in Perlis during her industrial training. Besides, she gained an opportunity to participate in a three months internship programme at HELP International's farm based Center for Ecology Research and Training, Canada. After graduation, she directly registered for a master degree in agronomy at the Department of Crop Science, Faculty of Agriculture, UPM in February 2013/2014. She has also been actively involved in non-government organization, HALUAN Malaysia as a volunteer since 2010 up to now.





## LIST OF PUBLICATIONS

- Noorhanin, D, Wahab, P. E. M., and Siti A. H. (2013). Response of different media ratio on growth and biomass production of *Andrographis paniculata* (hempedu bumi) grown under soilless culture system. *Transaction of the Malaysian Society of Plant Physiology*, 21, 12–18.
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