UNIVERSITI PUTRA MALAYSIA

EFFECTS OF DIFFERENT FERTILIZER APPLICATION REGIMES AND NITROGEN RATES ON WEED COMPOSITION, GROWTH PERFORMANCE AND YIELD OF FORAGE CORN

ZAHID OBAIDURAHMAN

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By

ZAHID OBAIDURAHMAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

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DEDICATION

TO MY BELOVED PARENTS AND FAMILY

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

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Faculty : Agriculture

Fertilizer management is an important consideration in corn production system because it is essential for the crop's growth and development. Moreover, another key focus for improving fertilizer use efficiency and increasing corn productivity is timing of fertilizer application at suitable crop growth stage. Furthermore, optimum nitrogen rates and plant density ensures the plants to grow properly both in their aboveground and belowground parts through efficient utilization of solar radiation and nutrients. In addition, weeds are one of the most important limiting factors in corn production, causing significant yield losses worldwide. The need to increase the supply of corn to meet with the increasing demand has called for better crop management practices including fertilizer and weed management strategies to enhance crop productivity. Therefore, two experiments were conducted in Field 15, Faculty of Agriculture, Universiti Putra Malaysia in open field. The first experiment evaluated two hybrid forage corn varieties (GWG888, CP888) responded to four fertilizer application regimes, namely T1 (applied at 1, 3 and 4 weeks after sowing (WAS)), T2 (2, 4 and 6 WAS), T3 (2, 4, 6 and 8 WAS), and T4 (2, 4. 8 and 10 WAS), to determine the best fertilizer application regime for corn growth, yield and weed management. In experiment 2, two levels of planting density (66667 Plants/ha and 76923 Plants/ha) as main plot and four levels of nitrogen fertilizer (120 kg/ha, 140 kg/ha 160 kg/ha and 180 kg/ha) as subplot were used to quantify the selected variety of forage corn growth and yield, and its effect on weed composition. The soil was thoroughly ploughed and pre-germinated seeds was sown in the field. The experiments were carried out in a split plot randomized complete block design with three and four replications, respectively. Data was recorded for number of leaves per plant, leaf area, plant height, chlorophyll content, cob length, number of cobs per plant, leaf, stem, cob and total plant fresh and dry matter yield, NPK, CP, NDF, ADF and lignin analysis in plant samples, number of weed species, weed population, weed flora composition and weed diversity index. Collected data were analyzed using SAS 9.4 software. The data were analyzed with variance analysis (ANOVA). Tukey's Honestly Significant Difference (HSD) was

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used to compare significant differences ($P \leq 0.05$) among treatments. Results of experiment 1 showed that both factors (fertilizer application regimes and variety) were significantly influenced corn growth, yield and weed composition. Results indicated that T3 for GWG corn variety produced the highest values of plant height, leaf area, total DM yield, and % of crude protein % as compared to other treatments. Meanwhile, T1 showed the lowest plant height, leaf area, DM yield and % of crude protein. The highest weeds density obtained from late application of fertilizers T4. Results from second experiment indicated that application of 160 kg N/ha in lower plant density (66667 Plants/ha) produced the highest leaves number, plant height, cob length, and N, P and K content, followed 180 kg N/ha and 140 kg N/ha and the lowest obtained from 120 kg N/ha. Although, fresh and dry yield was greater in higher plant density (76923 Plants/ha). In addition, the ADF, NDF, and lignin content were significantly decreased with the highest application of N (180 kg N/ha). As N rates increased, the species, population and diversity of weed enhanced. The highest weeds population was obtained when 180 kg N/ha was applied. In conclusion, based on results obtained, suitable fertilizer application regime of 160 kg N/ha (T3) improved corn growth and yield. Besides, optimum nitrogen rate (160 kg N/ ha) in higher density (76923 Plants/ha) enhanced corn production.

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

KESAN REJIM PEMAKAIAN BAJA YANG BERBEZA DAN KADAR NITROGEN TERHADAP KOMPOSISI RUMPAI, PRESTASI PERTUMBUHAN DAN HASIL JAGUNG FORAGE

Oleh

ZAHID OBAIDURAHMAN

Julai 2021

Pengerusi : Profesor Madya Muhammad Saiful bin Ahmad Hamdani, PhD
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Pengurusan baja merupakan pertimbangan penting dalam sistem pengeluaran jagung kerana penting bagi pertumbuhan dan perkembangan tanaman. Selain itu, satu lagi tumpuan utama untuk meningkatkan kecekapan penggunaan baja dan meningkatkan produktiviti jagung adalah masa permohonan baja pada peringkat pertumbuhan tanaman yang sesuai. Tambahan pula, kadar nitrogen yang optimum dan ketumpatan tumbuhan memastikan tumbuhan berkembang dengan baik di kedua-dua bahagian di atas dan di bawah tanah mereka melalui penggunaan sinaran dan nutrien yang cekap. Di samping itu, rumpai adalah salah satu faktor yang paling penting dalam pengeluaran jagung, menyebabkan kerugian hasil yang ketara di seluruh dunia. Keperluan untuk meningkatkan bekalan jagung untuk memenuhi permintaan yang semakin meningkat telah meminta amalan pengurusan tanaman yang lebih baik termasuk strategi pengurusan baja dan rumpai untuk meningkatkan produktiviti tanaman. Oleh itu, dua eksperimen dijalankan di Field 15, Fakulti Pertanian, Universiti Putra Malaysia dalam bidang terbuka. Percubaan pertama menilai dua jenis jagung hibrid (GWG888, CP888) memberi respons kepada empat rejim aplikasi baja, iaitu T1 (digunakan pada 1, 3 dan 4 minggu selepas menyemai (adalah), T2 (2, 4 dan 6), T3 (2, 4, 6 dan 8 adalah), dan T4 (2, 4. 8 dan 10), untuk menentukan rejim aplikasi baja terbaik untuk pertumbuhan jagung, hasil dan pengurusan rumpai. Dalam eksperimen 2, dua tahap ketumpatan penanaman (66667 tumbuhan / ha dan 76923 tumbuhan / ha) sebagai plot utama dan empat tahap baja nitrogen (120 kg / ha, 140 kg / ha 160 kg / ha dan 180 kg / ha) sebagai Subplot digunakan untuk mengukur pelbagai jenis pertumbuhan dan hasil jagung yang dipilih, dan kesannya terhadap komposisi rumpai. Tanah itu benar-benar dibajak dan benih pra-bercambah disemai di lapangan. Eksperimen telah dijalankan dalam reka bentuk blok lengkap plot split dengan tiga dan empat replikasi, masing-masing. Data direkodkan untuk bilangan daun setiap tumbuhan, kawasan daun, ketinggian tumbuhan, kandungan klorofil, panjang cob, bilangan cobs per tumbuhan, daun, batang, cob dan jumlah tumbuhan segar dan kering, npk, cp, ndf, adf dan Analisis Lignin dalam sampel

tumbuhan, bilangan spesies rumpai, populasi rumpai, merumput komposisi flora dan indeks kepelbagaian rumpai. Data yang dikumpulkan dianalisis menggunakan perisian SAS 9.4. Data dianalisis dengan analisis varians (ANOVA). Perbezaan Tukey yang signifikan (HSD) digunakan untuk membandingkan perbezaan yang ketara ($P \leq 0.05$) antara rawatan. Keputusan eksperimen 1 menunjukkan bahawa kedua-dua faktor (rejim aplikasi baja dan pelbagai) telah mempengaruhi pertumbuhan jagung, hasil dan komposisi rumpai. Keputusan menunjukkan bahawa T3 untuk pelbagai jagung GWG menghasilkan nilai tertinggi ketinggian tumbuhan, kawasan daun, jumlah hasil DM, dan% protein mentah% berbanding dengan rawatan lain. Sementara itu, T1 menunjukkan ketinggian tumbuhan terendah, kawasan daun, hasil DM dan% protein mentah. Ketumpatan rumpai tertinggi yang diperoleh daripada penerapan lewat baja T4. Keputusan dari eksperimen kedua menunjukkan bahawa penggunaan 160 kg n / ha dalam ketumpatan tumbuhan yang lebih rendah (66667 tumbuhan / ha) menghasilkan nombor daun tertinggi, ketinggian tumbuhan, panjang cob, dan n, p dan k kandungan, diikuti 180 kg n / ha dan 140 kg n / ha dan yang paling rendah diperoleh daripada 120 kg n / ha. Walaupun, hasil yang segar dan kering lebih besar dalam ketumpatan tumbuhan yang lebih tinggi (76923 tumbuhan / ha). Di samping itu, kandungan ADF, NDF, dan lignin telah berkurangan dengan ketara dengan aplikasi tertinggi N (180 kg n / ha). Seperti kadar n meningkat, spesies, penduduk dan kepelbagaian rumpai dipertingkatkan. Penduduk rumpai tertinggi diperoleh apabila 180 kg n / ha digunakan. Sebagai kesimpulan, berdasarkan hasil yang diperoleh, rejim aplikasi baja yang sesuai 160 kg N / HA (T3) pertumbuhan dan hasil jagung yang lebih baik. Selain itu, kadar nitrogen yang optimum (160 kg n / ha) dalam kepadatan yang lebih tinggi (76923 tumbuhan / ha) pengeluaran jagung yang dipertingkatkan.

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I certify that an Examination Committee has met on date of viva voce to conduct the final examination of Obaidurahman Zahid on his Master thesis entitled "Effects of Different Fertilizer Application Regimes and Nitrogen Rates on Weed Composition, Growth Performance and Yield of Forage Corn" in accordance with the universities and university college act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15th March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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LIST OF ABBREVIATIONS

AA	Auto Analyzer
AAS	Atomic Absorption Spectrophotometer
AD	Acid Detergent
ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
ANOVA	Analysis of Variance
CP	Crude Protein
DM	Dry Matter
FM	Fresh Matter
GAIN	Global Agriculture Information Network
HSD	Honestly Significant Difference
IV	Importance Value
ND	Neutral Detergent
NDF	Neutral Detergent Fiber
NIRS	Near Infrared Spectrophotometer
RCBD	Randomized Completely Block Design
SAS	Statistical Analyses System
UPM	Universiti Putra Malaysia
USDA	United States Department of Agriculture
WAS	Week After Sowing

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CHAPTER 1

INTRODUCTION

Corn, *Zea mays* (L.) is a grassy plant belonging to the family Poaceae and order Poales. Corn is grown in 166 countries on more than 175 million hectares (Amit et al., 2014). Worldwide, around 1087.2 million tonnes of corn are produced annually, highest among the major grain cereals (Engindeniz & Bolatova, 2018). A significant proportion of worldwide corn production is used for animal consumption as it provides billions of people in the developing countries as a valuable source of proteins and calories, mainly in Africa, Mesoamerica, and Asia (Shiferaw et al., 2011). Also, corn is an essential source of minerals and vitamins needed by our body (Huma et al., 2019).

Its various uses as food for human, animal feeding, and industrial raw material and the easiness of growing as a single crop or combined with other crops provide it an advantage over many other plants grown in a similar environmental zone (William et al., 2016). Besides, a corn develops well in different agro-ecologies and it is unmatched for any other crops because of its adaptability in various environments. Because of its diverse usages as human food and animal feeding, it has emerged as a globally important crop and functions as an important factor for different industrial products. Furthermore, corn is used in genetic studies as a model organism around the world (Lawrence et al., 2008).

Corn grown in Malaysia is mostly sweet corn varieties for human consumption. To maximize farmers' income, corn is grown in rotation with other crops including banana, sweet potatoes, pineapple, and a watermelon (GAIN Report, 2017). Crop improvement strategies for increasing biomass and yield, and site-specific nutrient best management practices are important to adapt to the changes and meet the new demands. Fertilizers have been successful in helping growers to achieve their high levels of production by supplying essential plant nutrients that are necessary for the production of adequate or healthier food for the growing population of the world (Chukwuka et al., 2015). Since corn is a fertilizer-exhausting crop, besides natural nutrient resources, additional nutrients must be provided by an appropriate fertilizer application (Shanker & Umesh, 2008).

Inorganic fertilizer applications exerted a significant influence on growth, development, and grain yield of corn (Amali & Namo, 2015). Furthermore, the time of fertilizer application has a considerable influence on crop yields as well. Suitable timing of fertilizer application enhances yields, decreases nutrient losses, increases the efficiency of nutrient usage, and avoids environmental harm. The recommendation of fertilizer dose and application time has been a continuous issue for researchers to solve and meet both nutrient requirements for the crop and preserves the production system (Shanker & Umesh, 2008). Wrong timing of fertilizer application can result in nutrient loss, fertilizer wastage, soil and water contamination, as well as harm to the crops. Besides this, the

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vital component of nutrient management is balanced nitration which plays a significant role in developing high-quality crops.

For major plant growth and yield development processes, in a balanced form, the availability of elements such as nitrogen (N), phosphorus (P), potassium (K), Sulphur (S), and manganese (Mg), etc. is important. Moreover, nitrogen is a vital plant nutrient and becomes a significant determining factor in the growth and production of corn (Subedi & Ma, 2005). Nitrogen is a crucial component of protein and nucleic acids, in which sufficient nitrogen application reduces the barrenness phenomenon and increases the shelling percentage (Amin, 2011). The application of nitrogen depends on the corn plants density in the field. It is important to calculate the plant density to determine the appropriate amount of fertilizers needed, particularly nitrogen for the crops to grow healthily and produce a high yield. Plant density is regarded among the most crucial cultural practices determining grain yield, as well as other main agronomic attributes of this crop (Sangoi & Bibliográfica, 2000).

The population of plants per unit area is the main determinant factor that affects plant growth and yield. The relationship between yield and spacing is complex. The yield increases when the number of total plants in specific areas increases and thereafter, the production of grain per plant drops. So, the optimization of the plant population has an important role in increasing the productivity of corn. In fact, in corn production, the use of random spacing has mostly resulted in low yield (William et al., 2016). Optimum plant density, water control, fertilization, and chemical input are necessary to improve the growth indicators that are accountable for high production (Shakoor et al., 2015). Furthermore, the population density of plants has significant effects on the vegetative and reproductive growth of corn. The yield of corn is poor with low planting density due to low plasticity in plant leaf area, but an over-dense plant standing will also greatly reduce corn growth and yield due to intraspecific competition for growth resources (Valadabadi & Hossein, 2009).

Another factor that influences the yield of corn is weeds. Weeds are inevitably a critical factor for the production of corn because it causes significant yield losses worldwide (Yeganehpoor et al., 2015). In the production of corn, weed interference is a serious problem, particularly at the beginning of the growing season, due to the slow early growth rate and broad spacing of the row. Weed management is essential to realize the yield capacity of corn. Weed species that infest the corn crop are the results of a dynamic connection between soil, weather, and cultural practices. These factors vary around regions and influence the composition and number of economically important dominant weeds for corn production (Amit et al., 2014). A number of weed species compete with corn plants and have been found to reduce yield by more than 65% with delays in the management of weeds. Increases in weed biomass, weed density, and weed species may cause crop yield losses to a great extent (Blackshaw et al., 2008).

Nutrient management practices of the crop are needed as a part of better management strategies of weeds (Tang et al., 2014a). Weeds and corn plants compete for resources

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including sunlight, nutrients, space, and humidity that affect crop morphology and phenology which reduces yield, causes harvesting difficulties and damage grain quality. Furthermore, the high infestation of weeds enhances the production costs, decreases the land value, and reduces the profits of corn producers.

The need to increase the supply of corn to meet with the increasing demand has called for enhanced practices of crop management such as fertilizer and weed management tactics to improve crop productivity. Soil low fertility and high weed infestation exists in Malaysia which causes losing of nutrients and high weed density. Thus, to overcome these problems there is a requirement to study appropriate fertilizer application and weed management practices. Therefore, the current study was initiated with the following objectives:

1) To investigate and compare the effect of fertilizer application regimes on weed composition, and growth and yield of two different hybrid corn varieties.
2) To quantify the effect of different nitrogen rates and plant densities on growth and yield of a selected hybrid corn variety, and weed composition.
3) To determine the effect of fertilizer application regimes, nitrogen rates and plant densities on nutrients content in hybrid corn varieties.

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LIST OF PUBLICATIONS

Zahid, O., Nazli, M.H., Jusoh, M., and Ahmad-Hamdani, M.S. (2021). Growth and Yield of Selected Forage Corn Hybrids and Weed Composition under Different Fertilizer Application Regimes. *Annals of Agri-Bio Research*, (Accepted).

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