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EFFECTS OF DIFFERENT TILLAGE SYSTEMS AND PLANTING DENSITIES ON SOIL PHYSICAL PROPERTIES AND YIELD COMPONENTS OF SWEET CORN (ZEA MAYS L.)

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By

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Chairman: Professor Desa Ahmad, PhD, P. Eng.

Faculty: Engineering

Sweet corn or maize (*Zea mays* L.) is the world's most important crops after wheat, barley and rice. This plant is nutritionally superior to other cereals in many ways, except in protein value. Considering the limitation of production resources and the increasing world population, efforts should be made to increase productivity of crop. Among the factors that influence corn productivity are planting density and tillage practices. In Malaysia, the rotary cultivator method which has been the common practice for sweet corn has some disadvantages and it would be worthwhile to compare it with other tillage methods. The shallow depth of ploughing and degradation of the soil because of intensive impact of the rotary blade with the soil has been identified as problems of this tillage method.

The main objective of this study was to find out the best tillage system or method in terms of soil physical characteristics, and then determining the crop yield of sweet corn as affected by different planting densities. In addition, the most economical tillage system in the field, optimum energy on drawbar power and engine fuel consumption for three tillage methods were also calculated.

Field experiments were conducted over two years (2008 and 2009) to investigate the effects of three tillage systems on selected soil physical properties at two depths of 0-15 and 20-35 cm in the Serdang series soil (*Typic Paleodult*). The research farm was located in the University Putra Malaysia (UPM) in Malaysia. It was under continuous corn planting for several years. The three tillage systems or methods were Moulboard Plough followed by once tandem disc harrowing (MPD), Disc Plough followed by once tandem disc harrowing (DP) and Rotary Cultivator only (RC) as control. Soil physical properties were measured two times, before and after soil tillage and included bulk density dry basis (BD_d), total porosity (P_t), aggregate size distribution ($Agg_d \geq 2mm$), mean weight diameter dry basis and wet basis (MWD_d and MWD_w), water infiltration (WI), moisture content volume basis (MC_v) and resistance to penetration (RP). At the end of the experiment, energy and fuel consumption utilized on the soil ploughed by the tillage systems were calculated.

The results showed that the measured soil physical properties at two depths of the plots (before tillage operation) were homogeneous at three plots and two depths. The highest value of crop yield at any given planting density occurred in MPD plot and decreased in DPD and RC plots, respectively in 2008 and combined two years. This result could be

due to lower BD_d and $Agg_d \geq 2mm$, higher MWD_w and P_t in upper layer (0-15 cm) for MPD plot. However WI was higher and RP was lower in RC plot at the same depth. The other reason for sweet corn reduction in RC plot could be higher BD_d and RP at the depth of 20-35 cm that impeded root growth of sweet corn; however MC_v was higher in lower layer. Depth of soil tillage by RC (15 cm) and creation of plough-pan below this depth (plough layer) was the other reason for the lower yield under RC.

Tillage method, planting density and also interaction effects of two factors, tillage and planting density were found to be significant on yield and some yield components of sweet corn such as ear diameter, row length of the kernels on the cob corn, fresh weight of ear con, yield of sweet corn and total weight of dry matter, in 2008. Similarly, all yield parameters except for ear diameter were affected by planting density and interaction of the two factors in 2009. Irrespective of planting density, corn yield was lowest in RC tillage in 2008 and for the combined two years. Crop yield with DPD was 8% higher than RC and with MPD it was 20% higher than RC. Ear diameter, row length of kernel on cob corn and weight of ear were higher at low density compared to high density planting. This could be due to the lower stress or competition between the plants for moisture, nutrients and sunlight under low density planting. Although the stress was higher for the plants with seed spacing of 20 cm; however it did not affect the crop yield and total weight of dry matter at any given tillage methods. This result revealed that there was no deficit of moisture and nutrients for the plants close to each other. Only the limitation of sunlight could be the reason for this finding. Climate or weather condition in 2009 was better than 2008 in terms of greater rainfall and sunshine hour. That is why the yield and some yield components of sweet corn were better in 2009 as compared to

2008 for DPD and RC plot.

Energy consumption on drawbar power was higher on the soil ploughed with DPD was 56.2 hp and decreased with MPD (52.5 hp) and RC (45.5 hp), respectively whilst fuel consumption was higher on the soil ploughed with MPD (27.02 L) and decreased to 25.69 L with DPD and 18.04 L with RC, respectively. Although energy on drawbar power and engine fuel consumption were higher under MPD and DPD tillage treatments as compared to RC, there was greater benefit gained in MPD plot (20%) and DPD plot (8%) respectively. On the other hand, the highest profit was obtained in MPD plot (RM 21,600) and this decreased to RM 19,500 in DPD plot and RM 18,100 in RC plot, respectively. In general, working condition of two tillage methods (MPD and DPD) was similar in trend in terms of soil physical properties, yield and its components of sweet corn. However, mouldboad plough to a depth of 25 cm followed by one time tandem disc harrowing to a depth of 10 cm with seed spacing of 20 cm showed the best overall results in terms of yield and economic benefit.

Key Words: Sweet corn, Mouldboard plough, Disc plough, Rotary cultivator, Soil physical properties, Plant density, Energy and fuel.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN SISTEM PEMBAJAKAN BERBEZA DAN KEPADATAN PENANAMAN KE ATAS SIFAT FIZIKAL TANAH DAN KOMPONEN HASIL JAGUNG MANIS

Oleh

HOSSEINALI TASH SHAMSABADI

Mac 2011

Pengerusi: Profosor Desa Ahmad, PhD, P.Eng.

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Jagung manis (*Zea mays* L.) merupakan tanaman terpenting dunia selain gandum, barli dan beras. Tanaman ini lebih tinggi kandungan nutrisi berbanding bijirin lain kecuali nilai protein. Mengambilkira kekangan sumber pengeluaran dan pertambahan penduduk dunia, usaha keras perlu dilakukan ke arah peningkatan hasil tanaman jagung manis. Antara faktor yang mempengaruhi peningkatan pengeluaran hasil tanaman jagung manis adalah kepadatan tanaman dan amalan pembajakan. Di Malaysia, kaedah tradisi bajakan putar bagi penanaman jagung manis mempunyai kekurangan dan adalah wajar dibandingkan dengan kaedah pembajakan lain. Pembajakan pada kedalaman cetek dan penghancurkan tanah akibat pukulan bilah bajak putar yang kuat dikenalpasti antara punca masalah penggunaan bajak putar tersebut.

Objektif utama kajian ini adalah untuk menentukan sistem pembajakan terbaik dari aspek ciri fizikal tanah dan hasil optimum dengan kepadatan tanaman berbeza untuk

hasil pengeluaran tanaman jagung manis yang lebih tinggi. Di samping itu, kaedah pembajakan paling ekonomik, tenaga optimum penggunaan kuasa drawbar dan penggunaan bahanapi turut diambilkira.

Bagi mencapai objektif penyelidikan, kajian ladang telah dijalankan untuk tempoh dua tahun (2008 dan 2009) untuk mengkaji kesan tiga jenis sistem atau kaedah pembajakan tanah ke atas sifat fizikal tanah pada kedalaman 0-15 dan 20-35 cm tanah jenis siri Serdang (*Typic Paleodult*) di ladang penyelidikan Universiti Putra Malaysia Serdang Malaysia. Kawasan tersebut adalah kawasan tanaman jagung untuk beberapa tahun. Kajian ini membandingkan tiga jenis sistem atau kaedah pembajakan tanah tanaman terdiri daripada Bajak Sepak diikuti dengan satu laluan Bajak Harrow Tandem (MPD), Bajak Cakera diikuti dengan satu laluan Bajak Harrow Tandem (DPD) dan Bajak Putar (RC) sebagai kawalan. Ciri fizikal tanah iaitu ketumpatan asas kering (BDd), jumlah keliangan (Pt), taburan saiz aggregat (Aggd>2mm), garis pusat beban min asas kering dan basah (MWDd dan MWDw), penyusupan air (WI), kelembapan asas isipadu (MCv) dan rintangan penusukan (RP) dianalisis dua kali sebelum dan selepas aktiviti pembajakan. Anggaran penggunaan tenaga dan penggunaan bahanapi bagi kawasan yang dibajak turut dikaji.

Keputusan hasil kajian menunjukkan bahawa ciri fizikal tanah pada dua kedalaman sebelum dan selepas pembajakan tidak menunjukkan perubahan yang nyata. Hasil tanaman tertinggi pada semua kepadatan berlaku dalam kawasan MPD dan berkurangan dalam kawasan DPD dengan diikuti oleh kawasan RC pada tahun 2008 serta purata kedua-dua tahun. Ini mungkin berpunca daripada BDd dan AGGd>2mm yang rendah,

MWDw dan Pt yang tinggi di lapisan atas (0-15 mm) bagi kawasan MPD. Walau bagaimanapun nilai WI adalah tinggi dan RP rendah bagi kawasan RC pada kedalaman yang sama. Pengurangan hasil jagung manis dalam kawasan RC berkemungkinan disebabkan oleh nilai BDd dan RP yang tinggi pada kedalaman 20-35 cm yang membantut pertumbuhan akar jagung manis manakala kelembapan MCv adalah tinggi di lapisan bawah. Kewujudan lapisan keras hasil bajakan putar RC juga boleh menjejaskan pertumbuhan akar tanaman tersebut dan mengurangkan hasil tanaman di kawasan RC.

Kaedah pembajakan, kepadatan tanaman dan kesan saling tindak dua faktor, kaedah pembajakan dan kepadatan tanah mempunyai kesan yang bererti ke atas hasil tanaman dan komponen hasil tanaman jagung manis seperti “diameter tongkol berisi”, “ panjang barisan bijian di atas tongkol”, “ bilangan barisan bijian di atas tongkol”, “ bilangan bijian bagi setiap barisan”, “ berat basah tongkol berisi”, hasil jagung manis dan berat “dry matter” pada tahun 2008 manakala pada tahun 2009, hanya “tongkol berisi” tidak dipengaruhi oleh kepadatan tanaman dan salingtindak kedua-dua faktor tersebut. Hasil terendah diperolehi dalam kawasan RC pada semua kepadatan tanaman dalam tahun 2008 dan gabungan tempoh dua tahun. Hasil tanaman kawasan DPD meningkat 8% dari kawasan RC manakala kawasan MPD meningkat 20% dari kawasan RC. “ Diameter tongkol berisi”, dan “berat tongkol berisi” meningkat dalam kawasan kepadatan tanaman rendah berbanding kepadatan tanaman tinggi .Ini berkemungkinan disebabkan oleh tekanan rendah atau persaingan antara tanaman terhadap kelembapan, nutrien dan cahaya suria pada kepadatan tanaman rendah. Walaupun tekanan adalah tinggi bagi tanaman dengan jarak 20 cm, ia bagaimanapun tidak mempengaruhi hasil tanaman dan berat “dry matter” pada apajua kaedah pembajakan. Keputusan ini menunjukkan ketiadaan pengurangan kelembapan dan nutrien bagi tanaman yang rapat antara satu

sama lain. Hanya kekurangan cahaya suria yang mungkin menyebabkan pencapaian sedemikian. Cuaca pada tahun 2009 (tahun kedua) adalah lebih baik berbanding tahun 2008 dari aspek jumlah hujan dan tempoh cahaya suria. Ini menyebabkan hasil dan komponen hasil jagung manis pada tahun 2009 lebih baik berbanding tahun 2008 bagi kawasan DPD dan RC. Penggunaan tenaga drawbar pada kawasan DPD adalah 56.2 hp dan menurun pada kawasan MPD (52.5 hp) dan RC (45.5 hp) manakala penggunaan bahanapi adalah tinggi bagi kawasan MPD (27.02 L) dan menurun kepada 25.69 bagi kawasan DPD dan 18.04 L bagi kawasan RC. Walaupun penggunaan tenaga adalah tinggi bagi kawasan MPD dan DPD berbanding RC, lebih banyak faedah diperolehi dalam kawasan MPD iaitu sebanyak 20% dan DPD sebanyak 8%. Keuntungan tertinggi diperolehi dari kawasan MPD (RM21,600) diikuti oleh kawasan DPD (RM19500) dan RM 18,100 bagi kawasan RC.

Secara umumnya, penggunaan kedua-dua kaedah pembajakan (MPD dan DPD) memberikan corak hasil yang sama mengenai sifat fizikal tanah, hasil dan komponen hasil tanaman jagung manis. Walau bagaimanapun penggunaan Bajak Sepak pada kedalaman 25 cm diikuti oleh satu laluan Bajak Harrow Tandem pada kedalaman 10 cm dengan jarak tanaman 20 cm memberikan hasil terbaik keseluruhan dari aspek hasil dan faedah ekonomik.

Kata kunci: Jagung manis, Bajak sepak, Bajak cakera, Bajak putar, Ciri fizikal tanah, Kepadatan penanaman, Tenaga dan Bahanapi.

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I certify that an Examination Committee has met on **Date** to conduct the final examination of **Hosseinali Tash Shamsabadi** on his **Doctor of Philosophy** thesis entitled "**Effects of different tillage systems and planting densities on soil physical properties and yield components of sweet corn (*Zea mays* L.)**" in accordance with Universiti Pertanian Malaysia Act 1980 and Universiti Pertanian Malaysia regulations 1981. The Committee recommends that the student be awarded the (Name of relevant degree).

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of **Doctor of Philosophy**. The members of the Supervisory Committee were as follows:

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DECLARATION

I hereby declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

HOSSEINALI TASH SHAMSABADI

Date: 3 March 2011

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