PROCEEDINGS

of the

Fourth Annual Students' Research Session

Department of Agricultural Engineering

Faculty of Agriculture

University of Peradeniya

Sri Lanka

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EDITOR'S MESSAGE

Throughout its history, the Department of Agricultural Engineering has nurtured the development of undergraduate students as emerging scholars in the field of Agricultural and Biosystems Engineering. During the final semester of the degree program, undergraduate students were interested in advancing research on self-learning, experimentation and industrial collaborations. The faculty serves as the mentors for them to turn up their ideas and to continue developing their own identities and pathways as graduates. We congratulate all undergraduate students for their commitment and efforts towards the successful completion of research.

The abstracts published in this volume were originally presented at the Undergraduate Research Thesis Presentation at the Department of Agricultural Engineering, on December 6th 2013, and subsequently edited for publication. This work represents a comprehensive effort by students and faculties to take a broad but critical look at to address burning issues in the local agro-industry and environment.

We hope that the finding of these researches will be help increase the agricultural productivity and sustainable management of natural resources while protecting the vital ecosystems in addition to training of nine qualified Agricultural and Biosystems Engineers to the country.

A. K. Karunarathna, Ph.D

MESSAGE FROM THE HEAD

DEPARTMENT OF AGRICULTURAL ENGINEERING

The great visionary, late Prof. V.E.A Wickramanayake has planted the seed 'Agricultural Engineering' in the faculty of Agriculture nearly 64 years back, knowing that it would be a large tree with a deep root system one day. With tremendous difficulties, the seed germinated and became a seedling as a 'Department' in 1975. Ever since, we had many great leaders to fertilize, irrigate & manage the plant into large tree as at present. Today I have been given the responsibility to contribute my share for the development of the Department and many more to continue in future. While giving my heartfelt respect to all those who contributed positively to bring the Department to the present level, I hope the blessings given to us by our teachers and great leaders of the Department would escort the Department towards the success for ever.

The discipline of Agricultural Engineering started mainly with farm machinery and soil & water engineering a few decades ago. This concept has widened to Biosystems Engineering, expanding its boundaries during the last two decades. Therefore, the student research themes in the Department have focused on engineering technology for sustainable agriculture with the vision of greening the agricultural sector. The research outcome is contributing to the agricultural industry with their unlimited practical applications.

Although, we are not still matured enough with respect to the publication of the final year research proceedings, the good start has brought us to a well matured state even at the 4th annual research session. As I believe, the secret behind this success is the team effort and the unity of the academic and academic support staff together with the majoring students in the Department.

Let me take this opportunity to congratulate all the Agricultural & Biosystems Engineering specialized students who have completed their research projects with a great success in 2013.

Professor D. A. N. Dharmasena
Head/Dept. of Agric. Engineering

BATCH OF STUDENTS MAJORING IN

AGRICULTURAL AND BIOSYSTEMS ENGINEERING (2012-2013)

M.R.I.A. Bandara

J.M.A.S. Jayawardana

G.M.P. Kumara

P.P.U. Kumarasinghe

G.H.T. Malintha

P. Panthusan

L.B.M.D.L. Priyadarshana

H.G.A. Udyani

K.H.G.K. Wishwajith

LIST OF EXTENDED ABSTRACTS

PERFORMANCE EVALUATION OF A REFUSE DERIVED FUEL GASIFIER FOR POWER GENERATION AT GOHAGODA, KANDY

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ABSTRACT

It is essential to develop alternative power generation technologies in Sri Lanka rather than depends heavily on high cost thermal power (fuel oil) and hydro power to cater the increasing demand. Gasification in principle which is run on a wider variety of input materials such as wood, municipal solid waste (MSW), refuse derived fuel (RDF), agricultural and industrial wastes, sewage sludge etc. can be used to produce a wider variety of output fuels. In order to feed the producer gas in to an internal combustion engine for generating electricity, the gas should be thoroughly cleaned and contain less moisture as well as less ash and other particulates.

A gasifier was designed and fabricated by the Ecotech Lanka Limited with the collaboration of University of Peradeniya at Gohagoda disposal site. Therefore, this research was aimed to design and develop a gas cleaning system for purifying the producer gas of the gasifier and to determine the power generation potential of the gasifier. The quality of coconut shells as the feedstock to the gasifier and charcoal produced by the gasifier was analyzed for moisture, ash and volatile matter contents. In order to purify the producer gas, a gas purification system that consisted of a wet scrubber, a cyclone separator followed by a fabric filter was designed, fabricated and coupled to outlet of the charcoal filter bed of the gasifier. The performance of the system was determined by analyzing the composition of inlet and outlet gas by using gas chromatography at the Institute of Fundamental Studies. Further, the gas inlet and the outlet flow rates and pressure were measured. Based on the collected data and reported values on calorific values of the coconut shells, different gaseous components and the final processed producer gas composition, the power generation potential of the gasifier under prevailed conditions was determined.

The moisture content of the coconut shells and charcoal was 16% (w/b) and 11±4.9% (w/b) respectively, the ash content was 2.99% and 36.26% respectively and the volatile matter% was 96% and 63% respectively. Water was sprayed from the top shower head at the rate of 138 cm^3/s while gas was sent in through the bottom inlet at the rate of 981.7 cm^3/s in to the wet scrubber. The humidity did

increase from 98% to 100% after the wet scrubber application due to absorption of moisture from the spraying water. The producer gas coming out of the wet scrubber did not flare or produced a flame when fired due to the high moisture content. Also, the temperature of the producer gas was reduced from $57^{o}C$ to $26^{o}C$ after applying the wet scrubber. The cyclone separator performed well, because lot of tar and particulates accumulated inside the collector bag. Also the humidity was reduced from 100% to 90.7% when gas went through from cyclone inlet to the outlet. The humidity of the producer gas was reduced from 90.7 to 86.6 when it did traverse through the dry cloth filter. Then the producer gas burnt continuously which reveals the flame is combustible and the fuel was in good condition. The composition of the cleaned gas was CO, H_2, CO_2, CH_4 and N_2 20%, 16%, 12%, 2% and 50% respectively which was similar to the theoretical values. According to the experimental and theoretical values about 50 kW can be generated by the gasifier at Gohagoda by using coconut shells as the feedstock and at 0.005 m^3/s inlet volumetric inlet air flow rate flow rate. It is necessary to conduct long term experimentations to determine mass balance of the system with different feedstock.

DESIGN AND DEVELOPMENT OF TEA LEAF HARVESTING MACHINE

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ABSTRACT

Sri Lanka rank is one of the oldest and best tea producing countries in the world. The tea produced in Sri Lanka is famous worldwide as "Ceylon Tea". Tea is the most popular warm beverage throughout the world and pre-eminent among plantation crops of Sri Lanka. Tea is the second largest and most important plantation crop in terms of foreign exchange earnings and employment generation in Sri Lanka. A major problem faced by the tea industry is the shortage of skilled labour for harvesting and the resulting increase in labour wages. Therefore mechanized harvesting offers an alternative solution to overcome the problem of labour shortage.

A reciprocating mechanism for cuter bar, a rotary reel to convey cut leaves in to the machine and a water proof cloth bag to collect cut leaves were incorporated to the initial design of the machine. Performance of the machine was checked by using motors with different size and speeds and blade with different materials and shapes. The final prototype was designed according to those results.

The weight of the final prototype was 1.6 kg and the cost of production was Rs.17000. The capacity of the machine was 6 kg/hour. The final prototype of tea leaf harvester has better output capacity than manual harvesting, easy to handle and cost effective.

MODELING THE EFFECT OF WATER STRESS ON PADDY YIELD USING APSIM

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ABSTRACT

Sri Lanka is a tropical country with two major cultivation seasons, called *Yala* and *Maha*. In between these two seasons, there are two intermonsoon periods. During these rainfall seasons, drought and flooding conditions are experienced in different parts of the island. Rice being the major staple food in Sri Lanka grows under different climate and environmental conditions. According to past experiences, climatic and environmental variability effect adversely on profitability and sustainability of rice cropping systems. Districts such as *Anuradhapura*, and *Ampara* grow paddy under drought conditions while districts such as *Gampaha* and *Kaluthara* grow under water logging conditions in addition to different soil types and soil properties. Therefore, it is commonly known that paddy cultivation in Sri Lanka is carried out under water stress conditions. The variability in paddy cultivation decision making process is very difficult and analyzing effect of different management options after the season is risk and additional cost to the farmer.

Crop models have been found to be very good methods for testing different decision making process and management option in crop cultivation. It needs less time and cost than field trials and has a possibility to change climate parameters and predict the yields. Agricultural Production Systems Simulator (APSIM) is a one of the best crop models used in present day in several cropping systems. APSIM was made in Australia according to their climate conditions. If Sri Lanka is going to use the model, accurate calibration and validation of the model according to our conditions is very much needed. During this research in *Kadaweramulla* area of the *Kurunegala* district, calibration and validation of BG-358 rice variety using APSIM software was carried out. In addition, the model was evaluated under different water management methods (Irrigation only, Rainfall only and Irrigation+Rainfall conditions) to identify water stress condition for paddy cultivation.

Model calibration was done using *Batalagoda* experimental data of BG-358 for the 2010 *Yala* season and calibration process was successful having a R^2 value of 97.6% between simulated and observed Leaf Area Index. Model validation was done using *Batalagoda* NCRVT data of BG-358 from 2005 to 2009 *Yala* seasons. The validation process was not much successful and R^2 was found to be 25.6%. The main reason for such a low value was lack of long term data for test the model. According to the results of different water management options, the simulated yield was higher under the irrigation + rainfall water management option compared to other two options. However, fields located in low land areas of the catena gave, high yield during without irrigation methods, as those areas have high moisture conditions than other areas.

REDUCTION OF BIOAVAILABILITY AND PHYTOTOXICITY OF Pb(II) AND Cu(II) IN CONTAMINATED SOILS USING CHITIN AND CHITOSAN

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ABSTRACT

Soil contamination with heavy metals becomes a serious concern not only for health hazards but also for ecotoxicity. As mitigation, wastewater treatment, appropriate use of agro-chemicals, sanitary landfills, soil amendments, use of permeable reactive barrier with biosorbent are proposed. Chitin, as a waste product in prawn industry, is a good absorbent for heavy metal. Chitin was prepared from outer skin of prawns after washing, drying and grinding. Pb and Cu contaminated soil samples were collected from shooting ranges.Shooting range soils are reported as highly contaminated with heavy metals,Pb, Cu and Sb. The objective of this research is to assess the potential of chitin in order to reduce bioavailable and phytotoxic of Pb and Cu in shooting range soils. Shooting soils were found with high concentrations of Pb and Cu at 20960, 857.2 mg/kg, respectively. Batch experiments, were conducted with chitin amendments of 0.5, 1, 2.5%. Pb and Cu concentrations were measured in solutions with time using AAS. Maximum amount of Pb and Cu release in unamended soil and amended were 56.2 and 15.1 mg/kg, respectively. Pb releasing capacity of chitin amended soils were lesser than the unamended soils. But releasing capacity of Cu in chitin amended soils higher than the unamend soils. Maximum percentage of release in 0 , 0.5, 1, 2.5% chitin amended soil, in the CaCl2 extraction was 0.24, 0.045, 0.02, 0.03 for Pb, and 0.07, 0.58, 0.17, and 0.24 for Cu, respectively, which showed the reduction of bioavailable Pb and release of Cu after the each treatment. Sequential data showed that the fraction of exchangeable for Pb is higher in unamended soils than the treated soils in the order of soil only $>$ 2.5% chitin $>$ 1% chitin$>$ 0.5% chitin. FTIR analyse revealedthat the possible adsorption sites for Pb and Cu are available on the chitn surfaces. Efficiency of adsorption directly depends on the functional groups of the adsobate. Chitin can adsorb 99% of Pb and 80% of Cu at pH 7 and $>$ pH 7. In addition chitin had no ionic strength dependancy, in the process of Pb and Cu adsorption. Mobilization of Pb(II) in soils have increased with increased chitin loadings. Most

effective chitin application among the tested 3 amendment loading was 0.5%. Among the pot experiment the highest plant growth rate recorded from 0.5% chitin and the lowest growth rate from 2.5% chitin added soils pots three weeks after germination. Chitin can be used as biosorbent to remove the Pb(II) and Cu(II) in polluted water without any ionic strength dependancy. Chitin as amendment in soil immobilize the Pb(II) while increse the mobility of Cu(II).

ESTIMATION OF CARBON STOCK IN TIMBER AND RUBBER PLANTATIONS: COMPARISON BETWEEN CONVENTIONAL AND REMOTE SENSING METHODS

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ABSTRACT

The global atmospheric carbon dioxide concentration has been increasing during last few decades and the world is experiencing the consequences such as global warming and climate change. Scientists and policy makers agreed on Kyoto Protocol to decrease the carbon dioxide emission through various activities. Carbon sequestration through tropical afforestation has been identified as the most important strategy of carbon sequestration. The Verified Carbon Standard (VCS) methodology which uses ground base data for estimation is the conventional method of carbon stock estimation in forest ecosystem. However, due to practical difficulties in acquiring ground base data, now the trend is to use remotely sensed data in carbon stock estimations.

The research was conducted in Khaya (*Khaya senegalensis*) and teak (*Tectona grandis*) plantations in Innamaluwa, and commercial rubber (*Hevea brasiliensis*) plantation in Eheliyagoda. The three growth parameters such as tree heights, Diameter at breast height (DBH), contents were measured on 20 x 20 m plots in all sites, following the VCS guidelines. The soil carbon content and non-tree biomass content were measured additionally in rubber plantations. The carbon content estimation was done based on VCS standard equations where the main tree growth parameter was DBH. The estimated tree biomass content of all three plantations was comparable with similar studies in other parts of the world, which confirm the validity of VCS method in Sri Lankan context.

The Landsat images for three research sites were obtained freely from United States Geological Survey (USGS) and images were processed to calculate the Normalized Difference Vegetation Index (NDVI) values for different vegetation types. Then, correlations were developed between obtained NDVI values and ground based biomass estimations. However, the comparison showed that the resolution of

images is lower than the field experiment plot sizes. Therefore, a good correlation between ground based estimations and remotely sensed data could not be established. Therefore it is recommended to use more precise land based measurements such as canopy area and high resolution satellite images such as IKONOS in future attempts to develop feasible methods for estimation of carbon stocks in Sri Lankan plantations.

DESIGN AND DEVELOPMENT OF A TRANSPLANTING MECHANISM FOR LEEK SEEDLINGS

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ABSTRACT

With the improvement of technology Farm mechanization can be considered as a valuable tool to improve profit or net income of the farmers. Leek is being cultivated in the up country wet zone and up country intermediate zone where the labor scarcity is high because of the plantation crop cultivation. Manual transplanting of leek seedlings consumes 45% of labor cost in leek cultivation. Leek growers in Sri Lanka are facing problems of labor scarcity and increasing labor wages. Therefore, objective of this project was to design and develop a transplanting mechanism for leek seedlings, suitable for Sri Lankan conditions. The transplanter should be lighter in weight, smaller in size and suitable to be used in the small terraced lands in the up country.

In this project, four prototypes were designed and tested to make a metering mechanism for leek seedlings. It was found that the ideas of using fully automated seedling metering used in designs of prototype one and the prototype two are not suitable for leek seedlings due to bent stems and varying stem sizes of seedlings. It was found that the prototype three can be improved in to workable mechanism if high technical support is given. The prototype four can also be improved with some modifications like using larger exiting tubes to prevent clogging due to bent stems.

DESIGN AND DEVELOPMENT OF A FAR INFARARED HEAT TREATMENT SYSTEM FOR DRYING AND ROASTING CHILLI

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ABSTRACT

Chili (*Capsicum annum*) is presently being roasted using conduction heating in electrically heated mechanical roasters. In this study, the possibility of using Far Infrared (FIR) radiation heating for roasting chili was investigated. The moisture content (MC), temperature and the color variation of chili pods at 3240, 3920, 5260 and 7188 W/m^2 FIR radiation intensities with exposure time were measured.

The higher the radiation intensitiy the highere the rate of moisture reductuion and rate of temperature rise. It takes 120 seconds to reduce MC of chili from 11% to 7%. Chili colour was reached the roasting colour in 60 seconds at 7188 W/m^2 and 120 seconds at 3240 W/m^2. Therefor FIR can be used in reducning moiatue content of chili and roasting at faster rates to meet the industrial needs of real time operations.

RESPONSE OF BG300 RICE VARIETY TO DIFFERENT AEROBIC WATER REGIMES

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ABSTRACT

Paddy can be processed into rice either as raw or parboiled forms. In parboiling process, conventional cold water soaking consumes 48-72 h depending on grain type and storage time. It has been reported that the moisture absorption rate of paddy grains under aerated soaking with water recirculation is relatively higher than soaking in standing water. Further studies have concluded that submerged aerated soaking is a viable solution for reducing effluent discharging issues while reducing the soaking time. Therefore, this experiment was conducted with the objective of distinguishing the effect of water recirculation & aeration on paddy soaking.

To achieve the above objective, one experiment was conducted to study the effect of water recirculation, with & without aeration on paddy soaking and another experiment was conducted to investigate the effect of pH on grain soaking. In addition to those two main experiments, the effect of paddy husk on moisture absorption was also tested using a newly harvested short grain paddy variety (BG 358). NH_4OH, CH_3COOH and $C_3H_6O_2$ were used to prepare solutions ranging from 4-11pH. Moisture contents of paddy and brown rice, pH and EC of effluent were measured during the experiment.

According to the results, water recirculation increased the moisture absorption but aeration while recirculation accelerated the moisture absorption further. The aeration increased the pH of soaking water slightly higher than un-aerated. Increase of the pH of soaking water increased the moisture absorption to the grain and paddy soaked in 11 pH reported a similar absorption rate as brown rice. Further, the husk controls only the initial moisture absorption rate and the rest is controlled by the diffusion rate of bran and the kernel
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THE SURVEY ON PERFORMANCE AND CUSTOMER SATISFACTION ON THE TEA CUTTER (PTC-600) MANUFACTURED BY JINASENA (PVT) LTD

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ABSTRACT

Quality of tea is reduced while being processed in the tea factory. When functioning machines for cutting process, it generates a high amount of heat. Then the tea made become from this process discolours. Jinasena Company has introduced a new tea cutter (PTC-600) to break bulk tea into small particles. Quality of the processed tea can be maintained at high standard using this tea cutter instead of using other methods used in the tea industry before. The general objective of this study is to evaluate customer satisfaction and find out their views on further improvements on tea cutter in mid country tea factories. The specific objectives are to determine the satisfaction levels of customers on performance of the tea cutter and to measure the satisfaction levels of customers on dealer services. Questionnaire based interviews with tea cutter buyers were used to collect data to fulfill the objectives. The codebook was prepared in computer software called 'Statistical Package for Social Sciences' to enter the data in the survey for analysis. Eleven tea factories used different methods to break bulk tea into smaller particles before the introduction of tea cutter by Jinasena Company. The average value of processed tea was Rs.282.50 without using the tea cutter and it was increased up to Rs.335.63 after using the tea cutter. Customers had given first priority on quality of the output. The survey results show the demonstrations conducted by Jinasena Company impacted the sale of tea cutter. Efficiency of producing output of particles sieved using sieve number eight is 38%. Majority of the customers are satisfied with the customer services of Jinasena Company. The major advantages of the tea cutter, as perceived by customers, are colour retain as black without converting brown and output can be taken according to current preferences in the market related to tea grades. The major disadvantages of the tea cutter are machine get blocked while functioning and it creates high amount of dust. Conveyer mechanism is suggested for feeding material. Measures for reducing dust emissions are recommended. A suction mechanism is one of the possible alternatives that could reduce dust emission. The stand of the tea cutter should be heavier than the present to prevent moving the tea cutter while functioning.