J. Trop. Agric. and Fd. Sc. 43(2)(2015): 145 – 153

Phytotoxicity of different organic mulches on emergence and seedling growth of goosegrass (*Eleusine indica*)

M. Dilipkumar[1], C.M. Mazira[2] and T.S. Chuah[2]

[1]Rice and Industrial Crops Research Centre, MARDI Seberang Perai, Locked Bag No. 203, 13200 Kepala Batas, Pulau Pinang, Malaysia
[2]School of Food Science and Technology, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

Abstract
The presence of abundant agricultural residues in Malaysia prompted the need to utilise these wastes to overcome environmental pollution. This study was conducted to determine the effects of organic mulches from the crop residues of oil palm, rice, coconut and pineapple on the shoot emergence and seedling growth of goosegrass (*Eleusine indica*). It was found that mulches from oil palm (frond, leaflet and rachis) and rice (husk) residues exhibited phytotoxic effects on goosegrass at different degrees of potency. The emergence and shoot fresh weight of goosegrass were inhibited by 85 – 100% when treated with oil palm residues at 3 t/ha. Comparatively, the rice husk exhibited 70 – 80% inhibitory effects at the same rate. The present findings suggest the possibility of using oil palm frond residues as organic mulches for the weed management programme.

Key words: organic mulch, oil palm residue, phytotoxicity, goosegrass

Introduction

Eleusine indica (L.) Gaertn., commonly known as goosegrass, is a monocot weed belonging to the Poaceae family and an important C4 grassy weed (Chauhan and Johnson 2008). It is widely distributed in the tropics and subtropical regions, particularly in Asia, Africa, South America, and the southern parts of North America (Neves 2011) and reported to be a problematic weed for 46 different crop species in more than 60 countries (Holm et al. 1991). In Malaysia, it is a noxious weed in orchards, vegetable farms, oil palm and rubber plantations (Chuah and Ismail 2010; Rosli et al. 2010). Recently, this species has become the most dominant weed in aerobic rice system (Rahman et al. 2012).

A single plant of goosegrass can produce up to 140,000 seeds; management failure can lead to increase weed seed bank in the soil (Chin 1979). The ability of goosegrass tolerance to some environmental stressors such as salt up to 50 mM NaCl, temperature up to 100 °C, pH from 5 to 10 (Chauhan and Johnson 2008) and moisture from 0.2 to 0.8 mp (Ismail et al. 2002) enable this species to survive throughout the year especially in tropical countries.

Although various means including mechanical, cultural, physical and biological control can be employed for weed management, the use of chemical control is more common because it is relatively cost-effective (Fongod et al. 2010). Various herbicides such as paraquat, glufosinate

Article history
Received: 3.11.2014
Accepted: 19.1.2015

Authors' full names: Dilipkumar Masilamany, Mazira Che Mat and Chuah Tse Seng
E-mail: dilip@mardi.gov.my

and glyphosate have been synthesised and utilised for this purpose. Unfortunately, excessive use of herbicides has led to environmental hazards and human health problems (Singh et al. 2006). Besides, it is further aggravated by a dramatic increase in the herbicide-resistant weed biotypes when a particular herbicide is used repeatedly in the same field year after year. To date, Heap (2014) documented about 434 unique cases (species x site of action) of herbicide-resistant weeds among 237 weed species (138 dicots and 99 monocots) around the world. Goosegrass is one of the species evolving resistance to many herbicides, which include dinitroaniline (Yamamoto et al. 1998), glyphosate (Powles 2008; Mueller et al. 2011); metribuzin (Brosnan et al. 2008), paraquat (Buker et al. 2002), glufosinate (Chuah et al. 2010), ACCase inhibitors (Osuna et al. 2012), dinitroaniline (McCullough et al. 2013), imazapyr (Valverde et al. 1993), metribuzin (Brosnan et al. 2008), pendimethalin, prodiamine and trifluralin (Nyporko et al. 2002).

Due to the resistance problems, alternative weed control method is needed. One of the alternative strategies might be through the application of mulch. Mulch has been defined as any material applied to the soil surface for protection or improvement of the area covered (Jordan et al. 2011). The term mulch is from the German-derived word 'molsch' which means 'soft' or 'beginning to decay' (Eddison 1994). According to Kumar and Lal (2012), mulches can be divided into two general groups either inorganic or organic. Inorganic mulches are those derived from materials that were never alive and are generally inert which include gravel, pebbles, plastic and landscape fabrics. Meanwhile organic mulches are composed material that derived from plant and animal such as crop residues (Case and Mathers 2006; Kruidhof et al. 2009; Chauhan and Abugho 2013), rumen-base (Iyagba et al. 2012), bark, shredded or chipped (Jodaugiene et al. 2006), newspaper (Sa´nchez et al. 2008) and straw (Singh and Saini 2008). Organic mulch by using crop residues is increasingly popular because it has a number of advantages in cropping system (Jodaugiene et al. 2006). For instance, it is available throughout the year, provides a better soil environment by conserving soil moisture, increases organic matter contents as well as nutrient availability to crops while maintaining soil fertility and inhibiting weed growth in crop fields (Uwah and Iwo 2011; Iyagba et al. 2012). In a previous studies, different types of crop residues such as cowpea, sorghum-sudangrass mulch, pine bark nugget, peat, wood chips, grass, straw and rice residues have been used to provide poor to excellent weed control (Jodaugiene et al. 2006; Singh and Saini 2008; Chauhan and Abugho 2012).

In the present study, therefore, a similar approach was investigated using residues of oil palm, coconut, rice and pineapple. These crops were selected based on their importance in the agricultural industry in Malaysia. The rapid development in the industry resulting in increase of fibrous wastes derived from harvesting of the crops, management practices and replanting operations. According to Agamuthu (2009), 1.2 million tonnes of agricultural wastes are disposed into landfill annually in Malaysia. Although residues from coconut and rice industries are commonly used as organic mulch, the testing of pineapple leaf and oil palm frond for weed management still warrant further investigation. Therefore, the main objective of this research was to evaluate the phytotoxic effects of leaflet, rachis and frond of oil palm and coconut, rice husk and pineapple leaf as organic mulches for suppression of emergence and shoot fresh weight of goosegrass.

Materials and methods

Seeds of the bioassay species, goosegrass were collected from wasteland of Gong Badak, Kuala Terengganu (5°24' 19"N; 130°05' 16"E) and propagated in a glasshouse, Universiti Malaysia Terengganu, Malaysia. Newly harvested seeds with at least 90% of germination rate were used for phytotoxicity test.

Four different types of crop residues namely oil palm frond, leaflet and rachis (*Elaeis guineensis* var. Tanera), coconut frond, leaflet and rachis (*Cocos nucifera* var. Malayan tall), pineapple leaves (*Ananas comosus* var. Sarawak) and rice husk (*Oryza sativa* var. MR 219) were used. Fresh oil palm fronds were collected from an oil palm plantation of the Federal Land Development Authority (FELDA) Chalok Barat, Terengganu, Malaysia (5°33'17"N; 102°43'17"E). The fronds were harvested from 35-year-old palm trees. The fresh coconut fronds were collected and harvested from 15-year-old coconut trees at MARDI Bachok, Kelantan, Malaysia (5°58'36"N; 102°25'36"E). Meanwhile, the fresh pineapple leaves were harvested from plants aged 13 months from the pineapple plantation at Bukit Putra, Terengganu, Malaysia (5°45'67"N; 102°84'03"E) and the rice husk samples were collected from MARDI Tanjung Karang, Selangor, Malaysia (3°25'0"N; 101°11'0"E). All crop residues were dried under direct sunlight for a month and ground into powder form (<2mm) using a mill (Nez ZFJ-200, Jiangsu, China) and then stored at room temperature (26 – 28 ºC) prior to use.

Kangkong soil series (76% silt, 23% clay, 1% sand, 0.4% organic matter and pH 4.91) was collected from a coconut farm, air-dried and passed through a 3-mm sieve. A 45 g sample of moist soil was filled in a plastic cup (4.5 cm diameter by 5 cm height) with holes at the bottom. A total of 20 seeds of goosegrass were sown evenly per cup at a depth of 1 cm into the soil. Each application of organic mulch was then applied onto the soil surface at 4 t/ha. This rate was chosen because it produces an optimal coverage of the soil surface (Uwah and Iwo 2011; Oliveira Jr et al. 2014). Non-treated goosegrass seeds were used as control treatment. The cups were placed in a 40 x 30 x 5 cm tray and water was applied from the bottom of the cups to stimulate moist conditions for proper growth of goosegrass seedlings. The trays were then placed in a glasshouse and maintained at a relative humidity of 78 – 80% and a temperature of 28 – 30 ºC with 12 h photoperiod and photosynthetic photon flux density (PPFI) of 800 ± 200 μE $m^{-2}s^{-1}$. All treatments were arranged in a completely randomised design with five replications. Emerged goosegrass seedlings were counted and recorded. Seedlings were considered emerged when the plumule attained a length of 1 mm. The shoot fresh weight of goosegrass was determined by harvesting and weighing above ground tissues remaining of each seedling after 1 month. All data were expressed as percentages of their respective controls.

The phytotoxicity test was repeated as described above with the treatments of rice husk, oil palm leaflet, rachis and frond at three different rates namely 0.7, 1.5 and 3 t/ha. Non-treated goosegrass seeds were used as control treatment. Each treatment was arranged in a completely randomised design with five replications. After a month, emerged seedlings were counted and shoot fresh weights were determined. The data were expressed as percentages of their respective controls.

Statistical analysis

All the percentage data in phytotoxicity test were subjected to analysis of variance (ANOVA) followed by Tukey's Studentized Range Test. Results were presented as the means ± standard deviation. The data of dose-response test were fitted to a log-logistic regression model by using sigma plot programme (SigmaPlot 2006 version 10.0) as follows (Kuk et al. 2002):

$$Y = d /(1+[x/x_o]^b)$$

Where, Y is percentage of shoot emergence or shoot fresh weight, d is the coefficients corresponding to the upper asymptotes, x is the rate of organic mulches, x_o is the rate of organic mulches that required to inhibit the shoot emergence or shoot fresh weight by 50% relative to untreated seeds and *b* is the slope of the line. Regression analyses were conducted and the x_o was calculated from the regression equations.

Results and discussion

A total of eight different types of organic mulches namely frond, rachis and leaflet of oil palm, frond, rachis and leaflet of coconut, pineapple leaf and rice husk were individually tested at 4 t/ha to determine the most phytotoxic potential organic mulch for the suppression of goosegrass. *Figure 1* shows that the response effect of shoot emergence and shoot fresh weight of goosegrass are varied with different types of organic mulches. It is documented that the shoot fresh weight was inhibited only by 5 – 10% when treated with coconut rachis or leaflet or pineapple leaf and the differences are not statistically significant as compared to the control treatment. Contrarily, significant inhibitory effects were found on the shoot emergence of goosegrass from the above mentioned treatments. This finding implies that these organic mulches act as a physical barrier, where it suppresses the shoot emergence of goosegrass. But once the weed successfully emerged through the mulch, it enjoys the same soil moisture conservation and other mulch benefits as does the established crop, resulting in increased of shoot fresh weight (Schonbeck 2012). This phenomenon also suggests that pineapple leaf, coconut rachis and leaflet may contain less allelochemicals constituents since there is no indication of phytotoxic on the shoot fresh weight of goosegrass.

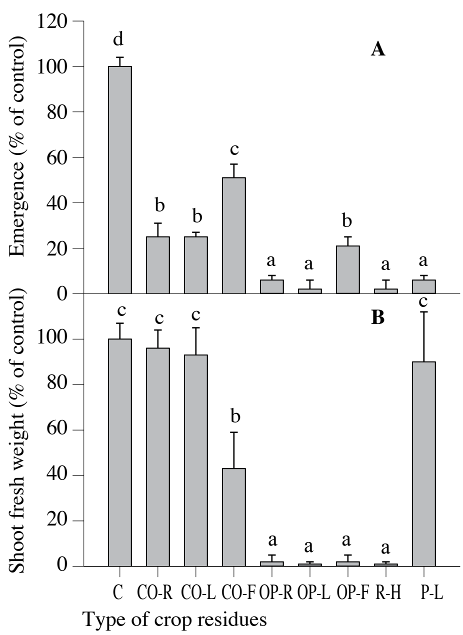

Figure 1. Phytotoxic activity of different crop residue mulches on emergence (A) and shoot fresh weight (B) of goosegrass at 4 t/ha, one month after pre-emergence application. C: control, CO-R: coconut rachis, CO-L: coconut leaflet, CO-F: coconut frond, OP-R: oil palm rachis, OP-L: oil palm leaflet, OP-F: oil palm frond, RH: rice husk, PL: pineapple leaves. Vertical bars represent standard deviation (SD) of the mean

This result agrees with other findings which indicates that certain organic mulches such as absinth wormwood mulch residue exhibits no phytotoxicity on shoot fresh weight of purple nutsedge and not different with untreated control treatment, but able to reduce purple nutsedge density by 68% (Anzalone et al. 2010). Organic mulches act as a physical barrier because it decreases light penetration and soil temperature, thereby resulting in inhibition of weed shoot emergence (Liebman and Mohler 2001; Kruidhof et al. 2009). On the other hand, the coconut frond was found to be having moderate inhibitory effects on the shoot emergence and shoot fresh weight of goosegrass by 47 and 57% respectively as compared to control (*Figure 1*). Coconut frond mulch exerted pronounced negative influence on the shoot fresh weight than their sole application of rachis or leaflet, probably due to the combined effects of allelochemicals contain in both leaflet and rachis. Similarly, Jamil et al. (2009) stated that a combination of different parts of crop residues with variety of allelochemicals, each having a different mode and site of action is more effective than application of individual part of crop residues. This might increase not only the number of susceptible sites, but also the concentration and uptake of allelochemicals.

It is interesting to note that the shoot emergence and shoot fresh weight of goosegrass were given higher reduction at least 80 and 95% respectively when treated with oil palm residues (leaflet or rachis or frond) or rice husk (*Figure 1*). These results imply that the residues of oil palm and rice may contain high level of allelochemicals that leads to a significant reduction in shoot fresh weight. Literature reports have indicated that the rice husk contains various types of allelochemicals. In was fact, the detection of allelopathic chemicals was reported earlier in the 70s by Kato et al. (1973) and Takahashi et al. (1976) who revealed two compounds of momilactone A and B, both isolated from rice husk (var. Koshihikari) and additional four compounds include ineketone, S-dehydrovomifoliol, momilactone-C and p-coumaric acid found in the similar rice husk cultivar (Kato et al. 1977). In addition, momilactones A and B extracted from rice husk have been reported to give high inhibitory effects on the germination of *Leptochloa chinensis*, *Amaranthus retroflexus*, *Cyperus difformis* (Chung et al. 2005), *Echinochloa cruss-galli* and *E. colonum* (Kato-Noguchi 2012; Kato-Noguchi and Ota 2013). According to Kato et al. (1973), this compound act as a growth inhibitor involved in seed dormancy. Besides, a number of secondary metabolites, phenolic acids, phenylalkanoic acids, hydroxamic acids, fatty acids, terpenes and indoles, were also identified in rice husk extracts (Rimando and Duke 2003). Unfortunately, it is not possible to discuss the allelochemicals properties of oil palm residues since this is the pioneer research revealing the current knowledge. Therefore, further study is essential to identify the allelochemical compounds involved in the phytotoxic activity of oil palm residues.

On the other hand, dose-response experiments of rice husk, leaflet, rachis and frond of oil palm residues showed high potential to inhibit the shoot emergence and shoot fresh weight of goosegrass (*Figure 2*). A 75% reduction in shoot emergence with respect to control (ED_{75}) was found to be at 2.0, 2.5, 2.6 and 2.9 t/ha when treated with leaflet, rachis, frond of oil palm and rice husk respectively (*Table 1*). Likewise, ED_{75} value for the shoot fresh weight required 1.5 – 2.5 t/ha of oil palm residues, however, rice husk needed more than 3 t/ha to achieve the same inhibitory effect (*Table 1*). This indicated that oil palm residues are more phytotoxic than that of rice husk on the emergence and growth of goosegrass. Since, rice husk mulch was widely used to control weeds in various crop fields (Dobermann and Fairhurst 2002; Xuan et al. 2003; Devasinghe et al. 2011; Jagmohan 2012), the present study has revealed the high potential of oil palm residues in weed management programme. Apart from the phytotoxic effects, it was also observed that at the rate of 0.75 t/ha, oil palm frond has stimulatory effect on the shoot fresh weight of goosegrass (*Figure 2*). Reports have shown abundant evidence that the response of a plant to a toxin is stimulation at low concentration (Inderjit and Duke 2003). However, as the concentration increases, the stimulation gradually turns to inhibition (Dilipkumar and Chuah 2013).

Table 1. ED_{75} values of goosegrass in relations to different types of crop residues mulches

Types of crop residues mulch (% of control)	*ED_{75} (t/ha)	
	Emergence	Shoot fresh weight
Oil palm leaflet	2.0391	1.4648
Oil palm rachis	2.4609	1.8750
Oil palm frond	2.6250	2.5078
Rice hull	2.9180	>3.000

*The organic mulching rate that reduces emergence and shoot fresh weight of goosegrass by 75%

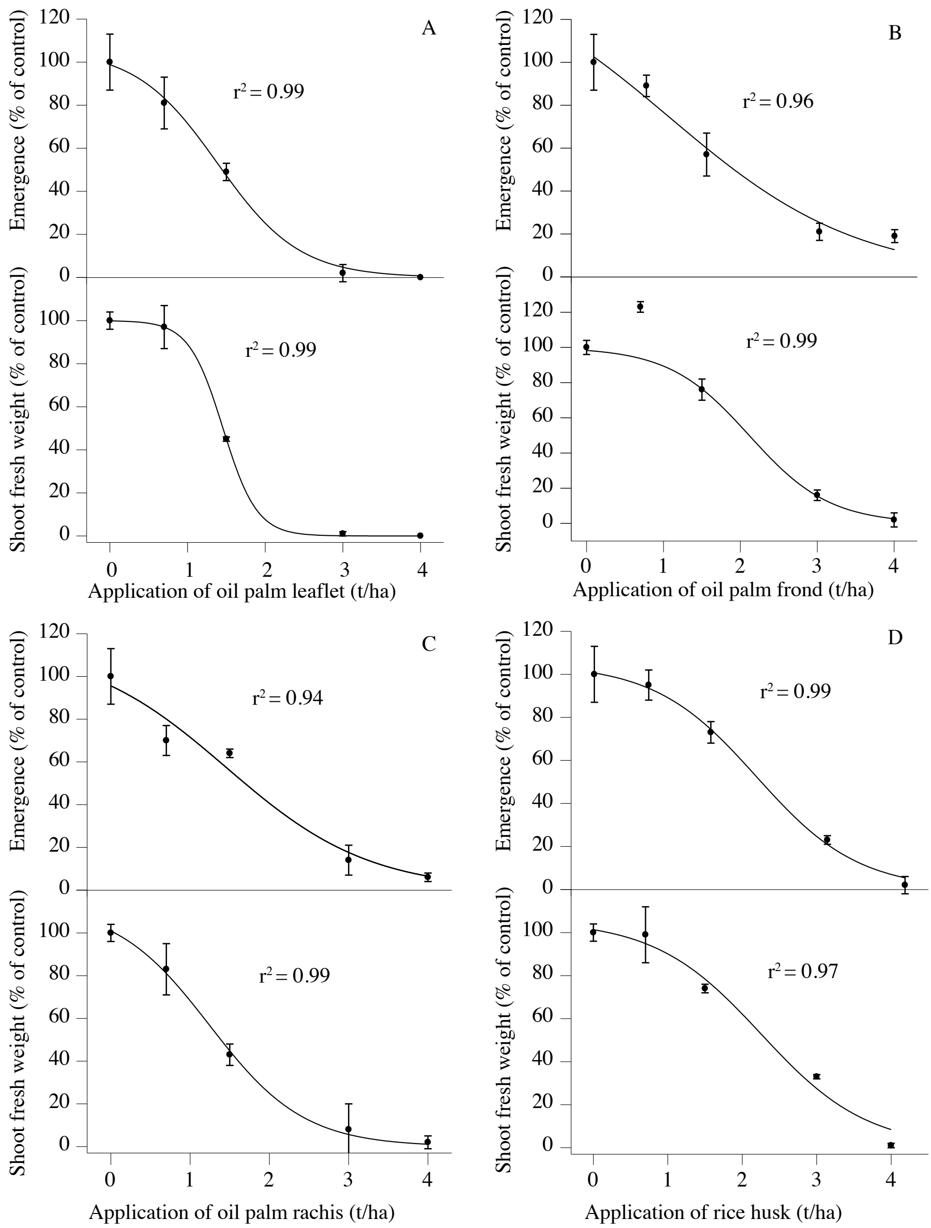

Figure 2. Effects of pre-emergence application of oil palm leaflet (A), oil palm frond (B), oil palm rachis (C) and rice husk (D) residue mulch on emergence and shoot fresh weight of goosegrass under glasshouse conditions. Vertical bars represent standard deviation (SD) of the mean (n =5). r^2 indicates regression model significant of the coefficient of determination at the 0.01 level of probability

Conclusion

In Malaysia, utilisation of pruned oil palm fronds are only limited by stacked around the base of the oil palm trees and across the slope as mulching material to improve soil fertility and reduce soil erosion (Moraidi et al. 2012). This study proved the herbicidal potential of oil palm residues on shoot emergence and growth of goosegrass. Therefore, more studies are required to evaluate the phytotoxicity of oil palm residues on other crops and weed species so that it can be utilised in various agricultural industries. Since this study was carried out under glasshouse conditions, caution should be taken regarding the ecological implications of the data because phytotoxicity of oil palm residues is influenced by biotic and abiotic factors in soil. Besides, studies on the isolation and identification of allelochemical compounds from oil palm residues especially the leaflet should be conducted to maximise their inhibitory effects on the development of bio-herbicide. In addition, it was suggested to use the oil palm frond in weed management programme, though oil palm leaflet exhibited a strong phytotoxic effect on goosegrass. This is because the preparation process for the oil palm frond powder is more practical, easy and cost effective if compared to that of oil palm leaflet.

Acknowledgment

This research was supported by the Ministry of Agriculture & Agro-Based Industry, Malaysia (RMK10: P-RI198).

References

Agamuthu, P. (2009). Challenges and opportunities in agro-waste management: An Asian perspective. *Proceeding of the inaugural meeting of first regional 3R forum in Asia*, 11 – 12 Nov. 2009, Tokyo, p. 4

Anzalone, A., Cirujeda, A., Aibar, J., Pardo, G. and Zaragoza, C. (2010). Effect of biodegradable mulch materials on weed control in processing tomatoes. *Weed technol*. 24: 369 – 377

Brosnan, J.T., Nishimoto, R.K. and DeFrank, J. (2008). Metribuzin-resistant goosegrass (*Eleusine indica*) in bermuda grass turf. *Weed Technol*. 22: 675 – 678

Buker, R.S., Steed, S.T. and Stall, W.M. (2002). Confirmation and control of a paraquat-tolerant goosegrass (*Eleusine indica*) biotype. *Weed technol*. 16: 309 – 313

Case, L.T. and Mathers, H.M. (2006). Herbicide treated mulches for weed control in nursery container crops. *J. Environ. Hort*. 24: 84 – 90

Chauhan, B.S. and Abugho, S.B. (2012). Interaction of rice residue and pre herbicides on emergence and biomass of four weed species. *Weed Technol*. 26: 627 – 632

—— (2013). Effect of crop residue on seedling emergence and growth of selected weed species in a sprinkler-irrigated zero-till dry-seeded rice system. *Weed Sci*. 61: 403 – 409

Chauhan, B.S. and Johnson, D.E. (2008). Germination ecology of goosegrass (*Eleusine indica*): an important grass weed of rain fed rice. *Weed Sci*. 56: 699 – 706

Chin, H.F. (1979). Weed seed – A potential source of danger. *Proceedings of the Plant Protection Seminar*, 22 – 23 Sept. 1979, Kuala Lumpur, (Kwee L.T., ed), p. 115 – 119

Chuah, T.S. and Ismail, B.S. (2010). The status of weed resistance in plantation crops of Malaysia. *The Planter* 86: 615 – 620

Chuah, T.S., Low, V.L., Cha, T.S. and Ismail, B.S. (2010). Initial report of glufosinate and paraquat multiple resistance that evolved in a biotype of goosegrass (*Eleusine indica*) in Malaysia. *Weed Biol. Manag*. 10: 229 – 233

Chung, I.M., Hahn, S.J. and Ahmad, A. (2005). Confirmation of potential herbicidal agents in hulls of rice. *Oryza sativa*. *J. Chem. Ecol*. 31: 1339 – 1352

Devasinghe, D., Premarathne K.P. and Sangakkara, U.R. (2011). Weed management by rice straw mulching in direct seeded lowland rice. *Trop. Agri. Res*. 22: 263 – 272

Dilipkumar, M. and Chuah, T.S. (2013). Is combination ratio an important factor to determine synergistic activity of allelopathic crop extract and herbicide? *Inter. J. Agri. Biol*. 15: 259 – 265

Dobermann, A. and Fairhurst, T.H. (2002). Rice straw management. *Better Crops International* 16: 7 – 11

Eddison, S. (1994). How to garden in the shade. In: *Taylor's guide to shade gardening*, p. 15 – 41. New York: Houghton Mifflin Company

Fongod, A.G.N., Focho, D.A., Mih, A.M., Fonge, B.A. and Lang, P.S. (2010). Weed management in banana production: The use of *Nelsonia canescens* (Lam.) spreng as non-leguminous cover crop. *African J. Environ. Sci. Technol.* 4: 167 – 173

Heap, I.M. (2014). International survey of herbicide resistant weed. Retrieved on 6 July 2013 from http://www.weedscience.org/Case/Case.asp?ResistID=5199

Holm, L.G., Plucknett, D.L., Pancho, J.V. and Herberger, J.P. (1991). *The world's worst weeds: Distribution and biology*. Hawaii: East-West Center by the University Press

Inderjit, K.L. and Duke, S.O. (2003). Ecophysiological aspects of allelopathy. *Planta* 217: 529 – 539

Ismail, B.S., Chuah, T.S., Salmijah, S., Teng, Y.T. and Schumacher, R.W. (2002). Germination and seedling emergence of glyphosate-resistant and susceptible biotypes of goosegrass (*Eleusine indica* [L.] Gaertn.). *Weed Biol. Manag.* 2(4): 177 – 185

Iyagba, A.G., Isirima, C.B. and Akonye, L. (2012). Influence of rumen-base organic mulch treatment on weed control and maize performance in rivers state, Nigeria. ARPN *J. Agricul. Biol. Sci.* 7: 524 – 526

Jamil, M., Cheema, Z.A., Mushtaq, M.N., Farooq, M. and Cheema, M.A. (2009). Alternative control of wild oat and canary grass in wheat fields by allelopathic plant water extracts. *Agron. Sustain. Develop.* 29(3): 475 – 482

Jodaugiene, D., Pupaliene, R., Urboniene, M., Pranckietis, V. and Pranckietiene, I. (2006). The impact of different types of organic mulches on weed emergence. *Agron. Res.* 4: 197 – 201

Jordan, A., Zavala, L.M., and Munoz-Rojas, M. (2011). Mulching, effects on soil physical properties. In: *Encyclopedia of agrophysics*, p. 492 – 495. Dordrecht: Springer Netherlands

Kato-Noguchi, H. (2012). Rice allelopathy and momilactone. *Pakistan J. Weed Sci. Res.* 18: 289 – 296

Kato-Noguchi, H. and Ota, K. (2013). Biological activities of rice allelochemicals Momilactone A and B. *J. Rice Res.* 1: 108

Kato, T., Kabuto, C., Sasaki, N., Tsugawa, M., Aizawa, H., Fujita, K., Kato, Y. and Kitahara, Y. (1973). Momilactones, growth inhibitors from rice. *Oryza sativa* L. *Tetrahedron Lett.* 39: 3861 – 3864

Kato, T., Tsugawa, M., Sasaki, N., Aizawa, H., Fujita, K., Kato, Y., Kitahara, Y. and Takahashi, N. (1977). Growth and germination inhibitors in rice husks. *Phytochemistry* 16: 45 – 48

Kruidhof, H.M., Bastiaans, L. and Kropff, M.J. (2009). Cover crop residue management for optimizing weed control. *Plant Soil* 318: 169 – 184

Kuk, I.Y., Kwon, O.O., Jung, H.I., Burgos, N.R. and Guh, O.J. (2002). Cross-resistance pattern and alternative herbicides for *Rotala indica* resistant to imazosulfuron in Korea. *Pestic. Biochem. Phys.* 74: 129 – 138

Kumar, S.D. and Lal, B.R. (2012). Effect of mulching on crop production under rainfed condition: A Review. *Int. J. Res. Chem. Environ.* 2: 8 – 20

Liebman, M. and Mohler, C.L. (2001). Weeds and the soil environment. In: *Ecological management of agricultural weeds*, p. 322 – 374. Cambridge: Cambridge University Press

Mandeep, S. and Jagmohan, S. (2012). Mulching with agro-waste: An alternate to agro-waste based power generation. *Inter. J. Elect. Eng.* 4: 163 – 166

McCullough, P.E., Yu, J. and Gomez de Barreda, D. (2013) Efficacy of preemergence herbicides for controlling a dinitroaniline-resistant goosegrass (*Eleusine indica*) in Georgia. *Weed Technol.* 27: 639 – 644

Moraidi, A., Teh, C.B.S., Goh, K.J., Husn, A.M.H. and Fauziah, I. (2012). Evaluation of four soil conservation practices in a non-terraced oil palm plantation. *Agron. J.* 104: 1727 – 1740

Mueller, T.C., Barnett, K.A., Brosnan, J.T. and Steckel, L.E. (2011). Glyphosate-resistant goosegrass (*Eleusine indica*) confirmed in Tennessee. *Weed sci.* 59: 562 – 566

Neves, S.S. (2011). Eleusine. In: *Wild crop relatives: Genomic and breeding resources*, p. 113 – 114. New York: Springer

Nyporko, A.Y., Yemets, A.I., Klimkina, L.A. and Blume, Y.B. (2002). Sensitivity of *Eleusine indic*a callus to trifluralin and amiprophosmethyl in correlation with the binding of these compounds to tubulin. *Rus. J. Plant Physiol.* 49: 413 – 418

Oliveira, Jr., Rios, R.S., Constantin, F.A., Ishii-Iwamoto, J., Gemelli, E.L. and Martini, P.E. (2014). Grass straw mulching to suppress emergence and early growth of weeds. *Planta Daninha*. 32: 11 – 17

Osuna, M.D., Goulart, I.C.G.R., Vidal, R.A., Kalsing, A., Ruiz Santaella, J.P. and De Prado, R. (2012). Resistance to ACCase inhibitors in *Eleusine indica* from Brazil involves a target site mutation. *Planta Daninha*. 30: 675 – 681

Powles, S.B. (2008). Review evolved glyphosate-resistant weed around the world: Lessons to be learnt. *Pest manag. Sci*. 64: 360 – 365

Rahman, M., Juraimi, A.S., Jaya Suria, A.S.M., Man, A.B. and Anwar, P. (2012). Response of weed flora to different herbicides in aerobic rice. *Scientific Res. Essays* 7: 12 – 23

Rimando, A.M. and Duke, S.O. (2003). Studies on rice allelochemicals. In: *Rice origin, history, technology and production*, p. 221 – 244. New Jersey: John Wiley & Sons

Rosli, M., Wahyu, W., Mohd Ghazali, M., Adam, B.P., Abdul, S.J., Yahya, A. and Mohammad. B.M.L. (2010). Management of mixed weeds in young oil-palm plantation with selected broad-spectrum herbicides. *Pertanika J. Trop. Agricul. Sci*. 33: 193 – 203

Sa´nchez, E., Lamont, W.J.Jr. and Orzolek, M.D. (2008). Newspaper mulches for suppressing weeds for organic high-tunnel cucumber production. *Hort. Technol*. 18: 154 – 157

Schonbeck, M. (2012). *Organic mulching materials for weed management*. Retrieved on 12 Sept. 2012 from https://www.extension.org/pages/65025/organic-mulching-materials-for-weed-management#.VBIFX2Ps36A

Singh, H.P., Batish, D.R. and Kohli, R.K. (2006). *Handbook of sustainable weed management*. New York: Haworth Press

Singh, M.K. and Saini, S.S. (2008) Planting date, mulch, and herbicide rate effects on the growth, yield, and physicochemical properties of menthol mint (*Mentha Arvensis*). *Weed Technol*. 22: 691 – 698

Takahashi, N., Kato, T., Tsugawa, M., Sasaki, N., Aizawa, H. and Kitahara, Y. (1976). Mechanisms of dormancy in rice seeds. II. New growth inhibitors, momilactone A and B isolated from the hulls of rice seeds. *Japan. J. Breed*. 26: 91 – 98

Uwah, D.F. and Iwo, G.A. (2011). Effectiveness of organic mulch on the productivity of maize (*Zea Mays* L.) and weed growth. *The J. Animal Plant Sci*. 21(3): 525 – 530

Valverde, B.E., Chaves, L., Gonzalez, J. and Garita, I. (1993). *Field-evolved imazapyr resistance in Ixophorus unisetus and Eleusine indica in Costa Rica. In: Brighton crop protection-Weeds*, p. 1189 – 1194. Hampshire: British Crop Protection Council

Xuan, T.D., Tsuzuki, E., Terao, H., Matsuo, M., Khanh, T.D., Murayama, S. and Hong, N.H. (2003). Alfalfa, rice-by-products and their incorporation for weed control in rice. *Weed Biol. Manag*. 3: 137 – 144

Yamamoto, E., Zeng, L. and Baird, W.V. (1998). α-Tubulin Missense Mutations Correlate with Antimicrotubule Drug Resistance in *Eleusine indica*. *American. Soc. Plant Physiol*. 10: 297 – 30

Abstrak

Penghasilan sisa pertanian yang banyak di Malaysia menggesa penggunaaan semula sisa ini bagi mengatasi masalah pencemaran alam sekitar. Kajian ini telah dijalankan untuk mengkaji kesan sungkupan organik daripada sisa-sisa tanaman kelapa sawit, padi, kelapa dan nanas terhadap kemunculan dan pertumbuhan rumput sambau (*Eleusine indica*). Hasil kajian mendapati bahawa sungkupan daripada sisa-sisa kelapa sawit (pelepah, rachis dan dedaun pelepah) dan padi (sekam) menunjukkan kesan fitotoksik rumput sambau pada kadar yang berlainan. Kemunculan dan berat basah dedaun rumput sambau terencat sehingga 85 – 100% apabila dirawat dengan sisa-sisa kelapa sawit pada kadar 3 t/ha. Secara perbandingan, sekam padi menunjukkan kesan perencatan sehingga 70 – 80% pada kadar yang sama. Hasil penemuan kajian ini mencadangkan potensi penggunaan sisa pelepah kelapa sawit sebagai sungkupan organik untuk program pengurusan rumpai.