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A Study on Germination and Early Seedling Growth of *Zea mays* L.in *Hibiscus sabdariffa* Linn. Extract Treated Medium

Mbosowo M. Etukudo[a]*, Anthony Egbe[b]

[a]*Department of Biology, Federal University Otuoke, PMB 126, Bayelsa State, Nigeria*

[b]*Department of Biological Sciences, Cross River University of Technology, Calabar, Cross River State, Nigeria*

[a]*Email: mbosombosowo@yahoo.com*

[b]*Email: egbetony@yahoo.com*

Abstract

Germination and early seedling growth of *Zea mays* in aqueous extract of *Hibiscus sabdariffa* calyces treated medium was conducted in the laboratory. The concentration levels of 20, 40, 60, 80, and 100% were prepared through serial dilutions, while 0% (distilled water) was used as control. Elemental composition of calyces of *H. sabdariffa* was determined using standard procedures. 10 seeds of the test crop were sown in sterilized Petri dishes containing two sterile What-Man's filter paper per treatment. Percentage germination and coefficient of velocity of germination counts were recorded at 24, 48, 72, and 96 hours after sowing all the seeds. Growth parameters such as shoot length, root length, fresh weight and dry weight of the seedlings were measured after 20 days. Elemental analysis of aqueous extract of *H. sabdariffa* calyces indicated the presence calcium, magnesium, sodium, potassium, phosphorus, nitrogen, iron, manganese, copper, zinc and lead in varied concentrations. The values of coefficient of velocity of germination and percentage germination of *Zea mays* were significantly ($P < 0.05$) decreased with increase in the concentration of *H. sabdariffa* extract, except at 20% concentration level of *H. sabdariffa* extract where slight stimulations were recorded in comparison with the control treatment. Similarly, the shoot length, root length, fresh weight and dry weight of maize seedlings were significantly ($P < 0.05$) decreased with increase in the concentration of *H. sabdariffa* extract, except at 20% concentration level of *H. sabdariffa* extract where the shoot length was slightly stimulated above that of the control treatment. This study suggests that aqueous extract of *Hibiscus sabdariffa* calyces could negatively affect the germination and early seedling growth of *Z. mays.*

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* Corresponding author.

Keywords: Germination; Growth; *Zea mays; Hibiscus sabdariffa;* Extract .

1. Introduction

Hibiscus sabdariffa belongs to the family Malvaceae, and in Nigeria, its cultivation is highly concentrated in the north eastern and middle belt regions of the country [1, 2]. It is an erect, slightly branched herb with smooth or hispid stem and glabrous, long-stalked and palmate leaves. The plant has tap root system which penetrate deep into soil, and its pedicellate flowers are usually large and coloured red to yellow [3]. It is an annual plant that thrives well in the tropics and usually grown in April or late August through seed propagation or other plant parts [4, 5].

The uses of *H. sabdariffa* include, the preparation of a non-alcoholic beverage known as "Zobo" from the calyces. It serves as tea and coffee substitute especially for people who are sensitive to stimulants [6]. It is also used for production of Jams, Jellies, sweet and sauces as well as colouring material for food and beverages [4]. The residue, which is obtained after removal of the oil is utilized as food either in soup or mixed with beans and other ingredients into cakes [2]. The seeds can be used as poultry and sheep feeds, while, the residue from the seed oil extraction can also be used as feeds for cattle and chicks [7]. The plant has relatively high contents of mineral elements such as K, Na, P, Mg, Ca, and Fe, as well as rich source of protein, fat, carbohydrate and vitamins [8, 9]. Ethnomedicinal benefits of this plant include the use of its flowers as an antiseptic, aphrodisie, astringent, cholagogue, demulcent, digestive, diuretic, emollient, laxative, cooler, sedative, and tonic [6, 10, 11]. The diuretic, choleretic and antihypertensive properties of the plant results from its contents of gossypectin, anthoxyanin glycoside, hibiscin and citric acid, which is found in the calyces [12]. *H. sabdariffa* is highly rich in vitamins, natural carbohydrate, protein, tannins, gums and other antioxidants including minerals. It is used as a remedy for abscesses, bilious conditions, cough, sores, wounds, dysuria and scurvy [1].

Various forms of chemical compounds have been reported to be constituents of plants parts (flowers, foliage, barks, roots and specialized structures) such as inorganic and organic compounds [13, 14, 15, 16]. These chemical compounds have much influence on seed germination, plant growth and development as they may stimulate or inhibit plant metabolic processes [17]. Organic wastes contain both micro and macro nutrients for plants growth and development, however, plant response to organic wastes treatment varies among different species [16]. Most of these organic compounds are secondary metabolites and among others belongs to terpenoids, phenolic compounds, organic cyanides and long chain fatty acids. Several biochemical reactions which regulate physiological processes have been affected due to the action of these organic compounds in target plants. Several studies have been conducted on allelopathic effects of some plants on seed germination and plant growth [18, 19, 20, 21]. In addition, studies on allelochemicals on physiological processes in plants have been reported [22]. The release of allelochemicals through leaching, liter decomposition, root exudation, or direct volatilization could positively or negatively affect germination and growth of other species [23].

There has been prevalent situation of improper disposal of the calyces of *Hibiscus sabdariffa* after their use in preparing zobo drink, with no consideration to their effects on surrounding crop plants. Therefore, this study was conducted to assess the chemical composition of *H. sabdariffa* calyces extract and its effects on the early

seedling growth of *Zea mays.*

2. Materials and Methods

2.1. Analysis of Sample and preparation of extract

Elemental and phytochemical composition of calyces of *Hibiscus sabdariffa* were determined using standard procedures [24]. 60 grams of macerated calyces of *H. sabdariffa* were weighed into the extraction bowls. 2 litres of boiled distilled water was poured into the bowl containing the *Hibiscus* sample and left overnight. The extraction was done by filtration and decantation. The plant extract was taken as the stock solution. The concentration levels of 20, 40, 60, 80, and 100% were prepared through serial dilutions, while 0% (distilled water) was used as control.

2.2. Germination and Growth Studies

Seeds of *Zea mays* obtained from local farmers in Yenagoa, Bayelsa State, Nigeria, were surface sterilized with 5% ethanol for 30 seconds and thoroughly washed several times with sterile distilled water. The seeds were air dried for few minutes. Ten (10) seeds of the crops were sown in sterilized Petri dishes each containing two sterile What-Man's filter paper based on the concentration levels examined. Germination and growth conditions were maintained at 28 ± 1^0C under light condition for 20 days. Percentage germination and coefficient of velocity of germination counts were recorded at 24, 48, 72, and 96 hours after sowing all the seeds. Growth parameters such as shoot length, root length, fresh weight and dry weight of the seedlings were measured after 20 days.

2.3. Statistical Analysis

The mean values were generated from the replicate readings and used to calculate standard errors. This was subjected to analysis of variance (ANOVA). The differences in the means were tested using Least Significant Difference (LSD) at 0.05 level of probability [25].

3. Results

The values of 40.62, 54.48, 60.76, 72.40, 8.78, and 0.68 mg/100g were recorded for calcium, magnesium, sodium, potassium, phosphorus and nitrogen contents in aqueous extract of *Hibiscus sabdariffa* (Table 1). Similarly, values for micro nutrients in the extract were 5.78, 4.36, 2.84, 4.68 and 0.012 mg/100g for iron, manganese, copper, zinc and lead (Table 1). The contents of phytate, flavonoid, tannin, alkaloid and saponin were 38.87, 32.74, 23.07, 15.39, and 14.62% (Table 2). The coefficient of velocity of germination of *Zea mays* was significantly ($P < 0.05$) increased (0.31) at 20% concentration level of *H. sabdariffa* extract above that of the control (0.28) (Table 3). Conversely, the values of coefficient of velocity of germination of *Z. mays* recorded at 40, 60, 80 and 100% concentration levels of *H. sabdariffa* extract decreased with increase in the concentration of the extract with values significantly lower than that of the control (Table 3). The values of percentage germination of the crop were significantly ($P < 0.05$) decreased with increase in the concentration of

H. sabdariffa extract. These values were significantly lower than that of the control, except at 20% level of concentration where the percentage germination of the crop was significantly higher than that of the control (Table 3). The values of 12.40, 13.10, 12.20, 11.36, 10.92 and 8.60cm were recorded for shoot length at 0, 20, 40, 60, 80 and 100% concentration levels of *H. sabdariffa* extract. The highest value (6.20cm) of root length of *Z. mays* was recorded at 0% concentration of *H. sabdariffa* extract while the lowest value (3.92 cm) was recorded at 100% concentration level of the extract (Table 4). The fresh weight of *Z. mays* was significantly ($P < 0.05$) decreased with increase in the concentration of the extract. These values were significantly lower than that of the control (Table 4). Similarly, the values of dry weight of *Z. mays* recorded at 20, 40, 60, 80 and 100 % concentration levels of *H. sabdariffa* extract decreased with increase in the concentration of the extract with values significantly lower than that of the control (Table 4).

Table 1: Elemental composition of *Hisbiscus sabdariffa* calyces extract

Minerals	Contents (mg/100g)
Calcium	40.62±0.77
Magnesium	54.48±0.60
Sodium	60.76±0.42
Potassium	72.40±0.19
Iron	5.78±0.20
Manganese	4.36±0.33
Copper	2.84±0.43
Zinc	4.68±0.85
Phosphorus	8.98±0.22
Lead	0.012±0.01
Nitrogen	0.68±0.07

Mean ± Standard Error from 3 replicates

Table 2: Phytochemical composition of *Hisbiscus sabdariffa* calyces extract

Phytochemical	Contents (%)
Alkaloid	15.39±0.22
Tannin	23.07±0.31
Saponin	14.62±0.27
Phytate	38.87±0.12
flavonoid	32.74±0.40

Mean ± Standard Error from 3 replicates

Table 3: Germination Parameters of *Zea mays* as affected by *Hisbiscus sabdariffa* extract treated medium

Concentration	**0**	**20**	**40**	**60**	**80**	**100**
Coefficient of velocity of Germination	0.28±0.04	0.31±0.03	0.23±0.07	0.22±0.01	0.20±0.02	0.20±0.24
Germination percentage (%)	80.40±0.53	82.48±0.40	79.25±0.64	77.50±0.49	75.82±0.32	72.82±0.44

Mean ± Standard Error from 3 replicates

Table 4: Growth Parameters of *Zea mays* as affected by *Hisbiscus sabdariffa* extract treated medium

Concentration	**0**	**20**	**40**	**60**	**80**	**100**
Shoot length (cm)	12.40±0.56	13.10±0.39	12.20±0.33	11.36±0.64	10.92±0.32	8.60±0.13
Root length (cm)	6.20±0.72	5.92±0.17	5.26±0.76	4.97±0.43	4.24±0.33	3.92±0.37
Fresh weight (g)	2.26±0.45	2.08±0.19	2.02±0.23	1.65±0.21	1.48±0.83	1.36±0.53
Dry weight (g)	0.34±0.01	0.32±0.06	0.30±0.04	0.28±0.02	0.26±0.42	0.21±0.48

Mean ± Standard Error from 3 replicates

4. Discussion

There were variations in seed germination and growth parameters of *Zea mays* among the various levels of concentration. The coefficient of velocity of germination and percentage germination were slightly stimulated at the lowest level of concentration of *Hibiscus sabdariffa* extract while germination parameters were inhibited at other levels of concentration of the extract. Seeds germination of *Cleome gynandra* has been reported to be stimulated by shoot extract of *Tithonia diversifolia* [26], while fresh aqueous extracts of *T. diversifolia* did not significantly inhibit the germination of maize [27]. However, the aqueous extract of *Vernonia amygdalina* and *T. diversifolia* was reported to inhibit percentage germination of maize [28]. Similarly, the different concentrations of water soluble leaf extracts of *Ricinus communis* and *Lantana camara* were shown to inhibit the germination and growth of maize [23]. Allelopatic substances are found in plant extracts, plant residues in soil, live plant exudates and as volatile gases liberated from plant organs such as leaves, rhizomes, flowers, fruits, and seeds [29, 30]. These substances have been reported to have direct effects on seed germination and

seedling growth [31, 32].The crop growth parameters; shoot length, root length, fresh weight and dry weight, decreased with increase in the concentration of the extract, although the shoot length was slightly stimulated at the lowest concentration of the extract relative to the control. Plant extracst have been shown to exhibit either positive or negative effects on other plants by exuding chemicals [33]. Therefore, the reduction in fresh weight of the crop may be attributed to imbalances in water uptake or osmotic balances of the tissues resulting from toxicity by allelochemicals [34]. In addition, phytochemical toxicity has been shown to cause root growth inhibition [17], suppression of seedling growth, and elongation of plumule [35]. The higher influence of allelochemicals on root growth than shoot growth has been supported by the fact that root is the first organ to absorb allelochemicals from the environment [36]. This inhibition effect on the root system may be due to greater permeability of allelochemicals to root tissue than that of the shoot tissue [37]. In general, extracts from various plants have been reported to exhibit various forms of influence on other plants, for instance, aqueous extracts of eucalyptus plant has been shown to inhibit seed germination, leaf and root length, dry and fresh weight of root and shoots of wheat cultivars [38].

Left over residues of sugar cane (ratooning) [39], rice [40] and many other crops have been reported to cause growth inhibition on the succeeding crops.The plant extracts of banana has been shown to inhibit the germination and early seedling growth of lettuce, red amaranth, radish, cucumber, ribbed guord, bean, and okra [41]. Similarly, *Hibiscus sabdariffa* aqueous methanol extracts have been reported to inhibit both shoot and root growth of cress, lettuce, alfalfa, timothy plant, Italian rye grass, crab grass, buck wheat, jungle rice, barnyard grass and sand fescue [42]. *H. sabdariffa* contains growth inhibitory substances and possess allelopatic activity [42]. Allelopatic effects of secondary metabolites occur in the early life cycle of plants, thereby resulting in inhibition of seed germination and seedling growth [38]. These compounds also exhibit various forms of mechanisms of actions with multiple phytotoxic effects [43].

5. Conclusion

This study shows that calyces of *Hibiscus sabdariffa* aqueous extract contains allelopatic substances that have direct effects on seed germination and early seedling growth of *Zea mays.* Phytochemicals such as alkaloid, phytate, tannin, flavoniod and saponin were present in calyces of *H. sabdariffa* in varied proportion. Although, growth stimulation and inhibition can be observed in some cases, this may be influenced by the concentration of the extract used.

6. Recommendation

Zea mays should not be grown where there is disposal of high concentration of *H. sabdariffa* calyce extract. There is need for proper disposal of calyces of *H. sabdariffa* during harvest in order to prevent inhibitory effects on surrounding crop plants.

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References

[1] G. Oboh and C.A Elusiyan. " Nutrient composition and antimicrobial activity of sorrel drinks (soborodo)." J Med. Food, vol**. 7** no. 3, pp. 340-342, 2004.

[2] N. C McClintock and M. El Tahir. "Hibiscus sabdariffa L." In Grubben G.J.H and Denton O.A Ed. Plant Resources of Tropical Africa 2. Vegetables. PROTA Foundation, Wageningen Netherlands/Backhuys Publishers: Leiden, Netherlands/CTA, Wageningen, Netherlands, 2004, pp. 321-329.

[3] O. B Dokosi (1998). Herbs of Ghana. Ghana Universities Press: Ghana, pp. 141 157.

[4] R.R Schippers. African Indigenous Vegetables. An overview of the Cultivated Species. Natural Resources Institute, Chatham:, UK, 2000, pp. 119-133.

[5] O.I Adejumo, A.A Alfa and A. Mohammed. "Physical Properties of Kano White Variety of Bambara Groundnut." Nigerian Academic Forum, vol. 12, no.1, pp. 68-77, 2007.

[6] Y.C Chang, K..X Huang ,A.C Huang, Y.C Ho and C.J Wang. "Hibiscus anthocyanins-rich extract inhibited LDL oxidation and oxLDL-mediated macrophages apoptosis." Food and Chemical Toxicology, vol. 44, no.7, pp. 1015–1023, 2006.

[7] K.M Elamin, H.E Hassan, H.O Abdalla, O.H Arabi, and A.A.T Eldar."Effect of feeding crushed Roselle seed (Hibiscus sabdariffa L.) (Karkadeh) on carcass characteristics of Sudan desert sheep." Asian Journal of Animal Science, vol. 6, no. 5, pp. 240–248, 2012.

[8] A. Ismail, E.H.K. Ikram and H.S.M. Nazri. "Roselle (Hibiscus sabdariffa L.) seeds nutritional composition protein quality and health benefits." Food, vol. 2, no. 1, pp. 1-16, 2008.

[9] .M. Nzikou, G. Bouanga-Kalou, L. Matos, F.B. Ganongo-Po, P.S. Mboungou-Mboussi, F.E. Moutoula, et al. "Characteristics and nutritional evaluation of seed oil from Roselle (Hibiscus sabdariffa L.) in Congo-Brazzaville**.** Current Research Journal of Biological Sciences, vol. 3, no. 2, pp. 141-146, 2011.

[10] C.C Chen, J.D Hsu, S.F Wang, H.C Chiang, M.Y Yang, E.S Kao, E.S., et al. "Hibiscus sabdariffa extract inhibits the development of atherosclerosis in cholesterol-fed rabbits." Journal of Agricultural and Food Chemistry, vol. 51, no.18, 5472–5477, 2003.

[11] S. Gosain, R. Ircchiaya, P.C Sharma, S. Thareja, A. Kalra, A. Deep et al., "Hypolipidemic effect of ethanolic extract from the leaves of Hibiscus sabdariffa L. in hyperlipidemic rats". Acta Poloniae Pharmaceutica, vol. 67, no.2, pp. 179–184, 2010.

[12] D.I McKay, C.Y, Chen, E. Saltzman, and J.B Blumberg. "Hibiscus sabdariffa L. tea (tisane) lowers blood pressure in prehypertensive and mildly hypertensive adults." The Journal of Nutrition, vol. 140,

pp. 298-303, 2010.

[13] A.C Dutta.. Botany for Degree Students. Oxford University Press: India, 2012, pp. 125-137.

[14] M.M Etukudo, E.M.I Roberts, and B.O Ilesanmi. "Some regulation of In vitro Growth of Bush mango- Irvingia wombolu Mildbr (Irvingiaceae)." World Research Journal of Agricultural Sciences, vol.1, no.2, pp. 7- 12 ,2014.

[15] M.M Etukudo, A. Hamilton-Amachree and E.M.I Roberts. "Eco-physiological Studies of Elemental and Proximate Contents of Gnetum africanum Welw and Telfairia occidentalis Hook seeds from two Ecological Zones of Akwa Ibom State." European International Journal of Science and Technology, vol. 4, no.6, pp.:47-53, 2015.

[16] M.M Etukudo, S.E Osim and A. Egbe, "Assessment Of fresh and dry cassava peels for chemical nutrients potentials or growth of Telfairia occidentalis Hook In Tropical soil." Journal of Advanced Scientific Research, vol. 7, no.1, pp. 49-52, 2016.

[17] S.U Chon, S.K. Choi, S.D. Jung, B.S. Pyo and M. Kims. "Effects of alfalfa leaf extracts and phenolic allelochemicalson early seedling growth and root morphology of alfalfa and barnyard grass." Crop Prot., vol.5, pp. 1077-1082, 2002.

[18] S. Sadeghi, A. Rahnavard and Z.Y Azhrafi. "Allelopathic effect of Helianthus annus (sunflower) on Solanum nigrum (Black Nightshade) seed germination and growth in laboratory condition." Journal of Horticultural Science and Ornamental Plants, vol. 2 no. 1, pp. 32–37, 2010.

[19] P. Oudhia. "Allelopathic effect of some obnoxious weeds on germination of soybean." Indian Journal of Plant Physiology, vol.5, no.3, 295–296, 2000a.

[20] P. Oudhia. "Germination and seedling vigour of Kodomillet as affected by allelopathy of Ipomoea carnea Jacq." Indian Journal of Plant Physiology, vol. 5 no. 4, pp. 383–384, 2000b

[21] P.S Vankar and J. Srivastava. "Comparative Study of Total Phenol, Flavonoid Contents and Antioxidant Activity in Canna indica and Hibiscus rosa sinensis, Prospective Natural Food Dyes." International Journal of Food Engneering, vol. 4, no. 3, pp.,1–17, 2008.

[22] R.R Barkosky and F.A Einhellig. "Allelopathic interference of plant -water relationships parahydroxybenzoic acid." Botanical Bulletin-Academia Sinica Taipei, vol. 44, pp. 53–58, 2003.

[23] R. Naz, and A. Bano. "Effects of allelochemical extracts from medicinal plants on physiological and biochemical mechanisms of maize (Zea mays L.) seedlings." International Journal of Agronomy and Agricultural Research, vol. 5, no. 2, pp.31-39, 2014

[24] A.O.A.C., Association of Official Analytical Chemist. Methods of analysis. 16h Edition, Washington

DC Press: U.S.A, 1999.

[25] I.U Obi. Statistical methods of detecting differences between treatment means and research methodology issues in laboratory and field experiments. AP Express publishers limited: Nigeria, 2002.

[26] D.M Musyimi, S.W Kahihu, D,K Buyela, and P.A Sikuku. "Allelopathic effects of Mexican sunflower [Tithonia diversifolia (Hemsl) A. Gray] on germination and growth of spiderplant (Cleome gynandra L.)." Journal of Biodiversity and Environmental Sciences, vol. 2, no.8, pp.:26-35, 2012.

[27] R.O Oyerinde, O.O Otusanya, and O.B Akpor. "Allelopathic effect of Tithonia diversifolia on the germination, growth and chlorophyll contents of maize (Zea mays L.)." Scientific Research and Essay, vol. 4, no.12, pp. 1553-1558, 2009..

[28] K.S Chukwuka, M.C. Obiakara and I.A. Ogunsumi. "Effects of aqueous plant extracts and inorganic fertilizer on the germination, growth and development of maize (Zea mays L.)." Journal of Agricultural Sciences ,vol. 59, no. 3, pp. 243-254, 2014.

[29] D.R Batish, K. Lavanya, H.P Singh and R.K Kohli. . "Root-mediated allelopathic interference of nettle-leaved goosefoot (Chenopodium murale) on wheat (Triticum aestivum)." J. Agronomy and Crop Science, vol. 193, pp. 37–44, 2007..

[30] M.R Asgharipour and M. Armin. "Inhibitory effects of Sorghum halepens root and leaf extracts on germination and early seedling growth of widely used medicinal plants." Advances in Environmental Biology, vol. 4 no.2, 316-324.

[31] S. Hussain, S. Siddiqui, S. Khalid, A. Jamal, A. Qayyum and Z. Ahmed. Z. "Allelopathic potential of Senna (Cassia angustifolia) on germination and seedling characters of some major cereal crop and their associated grassy weeds." Pak. J. Bot. vol. 39, pp. 1145-1193, 2007.

[32] M. Naseem, M. Aslam M, Ansar and M. Azhar. "Allelopathic effects of sunflower water extract on weed control and wheat productivity." Pakistan Journal of Weed Science Research, vol. 15, no.1, pp. 107-116, 2009.

[33] S.U Chon, Y. Kin and J.C. Kee. "Herbicidal potential and quantification of causative allelochemicals from several compositae weeds." Weed Res., vol. 43, pp. 444-450, 2003.

[34] U. Blum, R. Shafer and M.E Lemon. "Evidence for inhibitory allelopathic intraction including Phenolic acids in field soils: Concept vs. An experimental model." Crit Rev. Plant Sci., vol. 18, pp. 673-693, 1999.

[35] N.B Singh, S. Ranjana and R. Singh. "Effects of leaf leachate of Eucalyptus on germination, growth

and metabolism of green gram, black gram and peanut." Allelopathy J., vol. 11, pp. 43-52, 2003.

[36] M.A Salam, . and H. Kato-Noguchi. "Allelopathic potential of methanol extract of Bangladesh rice seedlings. Asian J. Crop Sci., vol. 2, pp. 70-77, 2010.

[37] N. Nishida, S. Tamotsu, N. Nagata, C. Saito and A. Sakai. "Allelopathic effects of volatile monoterpenoids produced by Salvia leucophylla: Inhibition of cell proliferation and DNA synthesis in the root apical meristem of Brassica campestris seedlings." J. Chem. Ecol., vol. 31, pp. 1187-1203, 2005.

[38] L. Ziaebrahimi, R.A. Khavari-Nejad, H. Fahimi and T. Nejadsatari. "Effects of Aqueous Eucalyptus Extracts on Seed Germination, Seedling Growth and Activities of Peroxidase and Polyphenoloxidase in Three Wheat Cultivar Seedlings (Triticum aestivum L.)." Pakistan Journal of Biological Sciences, vol. 10, pp. 3415-3419, 2007.

[39] C.H Chou. "Allelopathy in relation to agricultural productivity in Taiwan: Problem and prospects." In Allelopathy-basic and applied aspects, (ed.). Rizvi SJH & V Rizvi. Chapman and Hall: London. 1992, pp. 179-200.

[40] M.H.R Pramanik, T. Minesaki, T. Yamamoto Y., Matsui and H. Nakano. "Growth inhibitors in rice-straw extracts and their effects on Chinese vetch (Astragalus sinicus) seedlings." Weed Biol. Manage, vol. 1, pp. 133-136, 2001.

[41] S. Roy, M. Asaduzzaman, M.H.R. Pramanik and A. K. M. A. Prodhan. "Effect of banana plant extracts on germination and seedling growth of some vegetable crops." Bangladesh J. Crop Sci. vol. 17, no.1 ,pp. 235-242, 2006.

[42] P. Pukclai and H. Kato-Noguchi. "Evaluation of Allelopathic Activity of Hibiscus sabdariffa L." Advances in Biological Research, vol. 5, no.6, pp. 366-372, 2011.

[43] F. A. Einhellig. "The Physiology of Allelochemical Action: Clues and Views." In Allelopathy from Molecules to Ecosystems, Reigosa, M.J. and N. Pedrol Ed.. Science Publishers, Enfield: New Hampshire, 2002.