J. Sher-e-Bangla Agric. Univ., 12(1 & 2): 1-7, January & July 2021 ISSN 1997-6038

YIELD AND QUALITY OF POTATO AS INFLUENCED BY BIO-ADSORBENT IN ARSENIC TREATED SOIL

T. S. Roy[1], M. S. Rahman[2], M. Mostofa[3], M. Nahid[4] and M. A. Razzaque[5]

ABSTRACT

About 3 million hectare land of Bangladesh is covered by groundwater sources for irrigation and a significant portion of irrigation water is arsenic (As) contaminated. To produce safe potato under As contaminated soil, a pot experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2020 to April 2021 to find out the effect of rice husk as an bio-adsorbent to decontaminate As toxicity in potato. The experiment consisted of two factors. Factor A: Arsenic levels (4) *viz*., As_0: control (0 mg As kg^{-1} soil), As_1: 20 mg As kg^{-1} soil, As_2: 40 mg As kg^{-1} soil, and As_3: 60 mg As kg^{-1} soil. Factor B: Rice husk levels (4) *viz*., R_0: control (0 g kg^{-1} soil), R_1: 20 g kg^{-1} soil, R_2: 40 g kg^{-1} soil and R_3: 60 g kg^{-1} soil. The experiment was laid out in a randomized complete block design with three replications. Data were recorded on yield and some quality contributing parameters of potato. Results revealed that As and/or rice husk had significant effect on most of the yield and quality contributing parameters studied in this experiment. The result revealed that number of tubers $plant^{-1}$ gradually increased with increasing both As and rice husk levels. On the other hand, mean tuber weight decreased with increasing As level, but in case of rice husk and their combination had no effect this parameter. Yield of potato (g $plant^{1}$) gradually decreased with the increase of As levels while increased with increasing rice husk levels. The maximum yields (range 399.33- 416.67 g $plant^{1}$) were obtained from As_0R_2, As_0R_3, As_1R_1, As_1R_2 and As_1R_3 whereas, the minimum was from As_3R_3 (350.33 g $plant^{1}$). Specific gravity and dry matter content of both flesh and peel showed negative trends with increasing As levels in soil, vice-versa results were recorded from rice husk levels. The combined effects of As and rice husk had significant effect on specific gravity, but not on both flesh and peel dry matter content. The highest specific gravity (1.0749 g cm^{-3}) was observed from As_0R_2. Therefore, potato growers can grow potato up to 20 mg As kg^{-1} contaminated soil treated with 20 g rice husk kg^{1} soil, which contains safe As load than the critical one (0.157 mg As kg^{-1} FW) for human consumption.

Keywords: arsenic, bio-adsorbent, potato, rice husk, yield

INTRODUCTION

Arsenic (As) is a toxic metalloid element, this forms a number of poisonous compounds. The toxic metalloid As is widely distributed in nature, *eg*., in soil, water, air, plant, animal and human body. Arsenic contamination of surface and ground water occurs worldwide and has become a socio-economic issue in several parts of the globe. Recent research suggests that wide spread use of groundwater for irrigation is another route of As which enter the food chain and indirectly affect human health. Duxbury *et al*. (2003) mentioned the presence of As in food chain. The acute minimal lethal dose of As in adults is estimated to be 1 mg^{-1} kg^{-1} day^{-1} (Das *et al*., 2004). Recent studies suggest that a number of crops and vegetable plant species accumulate significant amount of As. The higher As accumulation was observed in arum, amaranth, radish, lady's finger, cauli flower and brinjal, whereas the lower level of As accumulation was observed in potato, beans, green chili, tomato, bitter guard, and turmeric, etc. due to the As-contaminated irrigation water. In their study on As around the world, reported that the As concentration in plants varied from less than 0.01 to about 5.0 g kg^{-1}. The concentrations of As in vegetables, such as *Colocasia antiquorum*, *Solanum tuberosum* and *Ipomea reptans* exceeded the food safety limits of 1.0 mg kg^{-1} (Abedin *et al*., 2002). Potato is the world's single most important tuber crop with a vital role in the global food system and food security (Brown, 2005). Bangladesh was the world's 8th largest producer of potatoes with a total production of about 97, 44,412 tons million ton in 2018 (FAOSTAT, 2019). Potato consumption as processed and fresh food is

[1]Professor, Dept. of Agronomy, [2]Assistant Professor, Dept. of Biochemistry, [4]M.S. Student, [5]Professor, Dept. of Agricultural Chemistry, Sher-e-Bangla Agricultural University, [3]Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

also increasing considerable in Bangladesh. People living in As affected areas are consuming contaminated potatoes that creates serious health problems. Bio-sorption technology includes metal removal performance for industrial waste water. This process is economical and eco-friendly compare with others (Lee *et al.*, 2009). It is a conventional technique for metal remediation. Bio sorption uses adsorbents derived from non-living biomass like sawdust, rice husk, egg shell etc. and removes toxic metals from industrial waste water and contaminated soil (Lee *et al.*, 2013). However, it is necessary to search for appropriate agricultural management practices to minimize the As content in potato tubers. Though the As accumulated in tubers is relatively lowers than other crops, the large consumption of it can cause a high risk to the human health of the population in As prone areas. With this in mind, the present research was aimed to study the response rice husk for changing the pattern of growth, tuber yield and minimizing As contamination in potato.

MATERIAL AND METHODS

The pot experiment was conducted at the research field of Sher-e-Bangla Agricultural University. The location of the site is 23.74^0N latitude and 90.35^0E longitude with an elevation of 8.2 meter from sea level. The experiment consisted of two factors. Factor A: Arsenic levels (4) *viz.*, As_0: control (0 mg As kg^{-1} soil), As_1: 20 mg As kg^{-1} soil, As_2: 40 mg As kg^{-1} soil, and As_3: 60 mg As kg^{-1} soil. Factor B: Rice husk levels (4) *viz.*, R_0: control (0 g kg^{-1} soil), R_1: 20 g kg^{-1} soil, R_2: 40 g kg^{-1} soil and R_3: 60 g kg^{-1} soil. Sodium arsenate (Na_3AsO_4) was used as a source of As, The two factors experiment was laid out in a randomized complete block design with five replications. Rice husk was collected from a rice mill. The collected soil was sandy loam. Soil pH and organic carbons were 5.8 and 0.44%, respectively. The experimental soil of basket was fertilized with a recommended dose of N, P, K, S, Zn, B and cowdung @ 575 µg, 345 µg, 750 µg, 108 µg, 18 µg, 8.75 µg and 50 g, respectively, per 10 kg soil (Mondal *et al.*, 2011). The certified grade seed tuber of "Courage" variety was used as planting material. Collected seed potato tubers were kept at room temperature to facilitate sprouting. The properly sprouted, healthy, and uniform sized (60-70 g) seed potato tubers were planted according to treatment and an entire Potato planted in each basket. Seed potatoes were planted on an average 5-6 cm depth in the basket. All the intercultural operations and plant protection standards were taken as per Tuber Crops Research Centre recommendation. Haulm pulling was done at 90 DAP when the majority of plants showed senescence and the tops started drying. After haulm pulling, the tubers were kept under the soil for 10 days for skin hardening. The Potatoes of each basket were separately harvested, bagged, tagged and brought to the laboratory for further analysis. All yield contributing parameters were calculated as per Tuber Crops Research Centre, BARI, Bangladesh. The yield and yield contributing parameters *viz.*, number of tubers $plant^{-1}$, mean tuber weight and yield (g $plant^{-1}$) were collected as per treatments. The following quality parameters were determined.

Dry matter content

The samples of tubers were collected from each treatment. After peeling off the tubers from each treatment, separately peel and flesh were dried in a drying oven at 72°C for 72 hours. Dry matter content was calculated as the ratio between dry and fresh weight and expressed as a percentage (%). The dry matter percentage was calculated with the following formula.

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} X\ 100$$

Specific gravity

The fresh weight of the tuber was taken first. Then the samples of tuber were sunk in a full water fill beaker. The tuber removed the equal volume of the water. The removed water weight was taken and the specific gravity of tuber was calculated with the following formula:

$$\text{Specific gravity} = \frac{\text{Weight of fresh tuber}}{\text{Weight of equal volume of water removed by tuber}}\ g\ cm^{-3}$$

Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among different treatments. The analysis of variance of all the recorded parameters performed using Statistics-10 software. The difference of the means value was separated by Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield and yield contributing parameters

Number of tubers plant^{-1} varied significantly different with arsenic (As) and/or rice husk levels. The results indicated that the number of tubers hill^{-1} gradually increased with increasing As levels similar trends were also found in rice husk levels (Tables 1 & 2). The highest number of tubers plant^{-1} was recorded in As_3R_3 (13) which was statistically similar to As_2R_1, As_2R_2, As_2R_3, As_3R_0, As_3R_1, As_3R_2, respectively while, the lowest was found from $As_0 R_0$ (6) (Table 3). The mean tuber weight decreased with increasing As levels, but rice husk level and their combination had no effect on this parameter. Though the yield of tuber progressively decreased with increasing As level while up to 10 mg As kg^{-1} soil, yield remained statistical similar. The yield decreased due to high concentration of As in soils. Carbonell-Barrachina *et al.* (1998) observed that yield increases due to small additions of As for corn, potatoes, rye and wheat. The decrease in yield was caused by increasing levels of heavy metals. This is in agreement with conclusion by Ducsay (2000) in his work; he referred to phytotoxic effects of heavy metals on plants, which decrease their yields and quality. Growth stimulation by As does not always occurs, is sometimes only temporary, and may result in the reduction of top growth. Two possibilities exist for growth stimulation by As: first, stimulation of plant systems by small amount of As, since other pesticides, such as 2, 4-D, stimulate plant growth at sub-lethal dose; second, displacement of phosphate ions from the soil by arsenate ions, with the resultant increase of phosphate availability (Jacobs and Keeney, 1970). Hussain (2012) stated that application of 10 mg As kg^{-1} soil increased the most yield contributing characters of potato. This result agreed with Hussain (2012).

Table 1. Effect of Arsenic levels on yield and yield component of potato cv Courage

Treatments	No. of tubers plant^{-1}	Mean tuber wt.(g)	Yield (g plant^{-1})
As_0	7.00 d	56.68 a	401.67 a
As_1	9.33 c	43.41 b	396.75 a
As_2	11.00 b	36.194 c	384.92 b
As_3	13.08 a	27.18 d	352.25 c
CV (%)	11.84	13.89	2.38
LSD (0.05)	1.00	4.73	8.89

In a colums means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. As_0: Control, As_1: 20 mg As kg^{-1} soil, As_2: 40 mg As kg^{-1} soil, As_3: 60 mg As kg^{-1} soil.

Table 2. Effect of rice husk levels on yield and yield component of potato cv Courage

Treatments	No. of tubers plant^{-1}	Mean tuber wt.(g)	Yield (g plant^{-1})
R_0	8.99 c	42.17	367.50 c
R_1	10.17 ab	41.49	380.58 b
R_2	10.08 ab	41.04	392.00 a
R_3	10.92 a	38.76	395.50 a
CV (%)	11.84	13.89	12.38
LSD (0.05)	1.00	NS	8.89

In a colums means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. NS= Non-significant, R_0- 0 g rice husk kg^{-1} soil, R_1-20 g rice husk kg^{-1} soil, R_2-40 g rice husk kg^{-1} soil, R_3-60 g rice husk kg^{-1} soil

The yield of tuber gradually increased with increasing rice husk level because of improving aeration and water holding capacity and reducing soil temperature. Table 3 showed that the maximum yield was recorded from the combination of As_1R_3 (416.67 g plant^{-1}) which was statistically similar to As_0R_2, As_0R_3, As_2R_3 and As_1R_2 treatments while the minimum was obtained from As_3R_3 (Table 3). Therefore, these results support that As upto 20 mg As kg^{-1} soil increase fresh potato yield and rice husk also increase yield than control condition.

Table 3. Combined effect of Arsenic and rice husk on yield and yield component of potato cv Courage

Treatment combinations	No. of tubers plant^{-1}	Mean tuber wt.(g)	Yield (g plant^{-1})
$As_0 R_1$	6.67 f	60.60	395.67 cd
As_0R_2	7.33 ef	57.44	410.33 a-c
As_0R_3	7.67 ef	54.89	415.67 ab
As_1R_0	8.33 d-f	45.56	371.00 e-g
As_1R_1	9.33 c-e	43.08	402.67 a-c
As_1R_2	9.33 c-e	44.06	404.67 a-c
As_1R_3	10.33 b-d	40.93	416.67 a
As_2R_0	9.00 de	43.00	365.67 f-h
As_2R_1	11.33 a-c	33.55	376.67 ef
As_2R_2	11.33 a-c	35.45	398.00 b-d
As_2R_3	12.33 ab	32.77	399.33 a-d
As_3R_0	12.33 ab	26.34	348.33 h
As_3R_1	13.33 a	26.936	355.33 gh
As_3R_2	12.33 ab	28.99	355.00 gh
As_3R_3	13.33 a	26.44	350.33 h
CV (%)	11.84	13.89	12.38
LSD (0.05)	2.01	NS	17.77

In a colums means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. NS= Non-significant, As_0: Control, As_1: 20 mg As kg^{-1} soil, As_2: 40 mg As kg^{-1} soil, As_3: 60 mg As kg^{-1} soil. R_0- 0 g rice husk kg^{-1} soil, R_1-20 g rice husk kg^{-1} soil, R_2-40 g rice husk kg^{-1} soil, R_3-60 g rice husk kg^{-1} soil

Quality contributing parameters

Specific gravity of tuber

Specific gravity of tuber varied significantly with different As and/or rice husk levels (Tables 4, 5 & 6). The result showed that the specific gravity gradually decreased with the increase of As levels. The peak specific gravity of tuber recorded from As_0 (1.066 g cm^{-3}), which was statistically similar to As_1 (1.064 g cm^{-3}), while the minimum was in As_3 (1.01 g cm^{-3}) (Table 4). Table 5 exhibited that specific gravity of tuber increased with increasing rice husk level (Table 5). The experiment indicated that soil treated with R_3 (60 g Rice husk kg^{-1}) produced the maximum specific gravity of tuber which was statistically similar to R_2 and R_1. Specific gravity of tuber was also significantly influenced by the treatment combinations of Arsenic and rice husk levels. The maximum specific gravity of the tuber was observed in As_0R_2 (1.07 g cm^{-3}) which was statistically similar to $As_0 R_0$, $As_0 R_1$, As_0R_3, As_1R_0, As_1R_1, As_1R_2 and As_1R_2 while the minimum was found in As_3R_0 (0.95g cm^{-3}) (Table 5). With the increase of Arsenic levels, the specific gravity of the tuber was decreased but in the case of rice husk application, the specific gravity of tuber slightly increased. A high concentration of Arsenic may decrease specific gravity (Freeman *et al.*, 1998). So, when sawdust levels were increased, the accumulation of Arsenic was decreased and the potato plant was able to uptake more P, which increased specific gravity in the tuber.

Dry matter content of tuber flesh and peel

Application of different levels of Arsenic had significant effect on both tuber flesh and peel dry matter content (Table 4). The results revealed that the specific gravity decreased with increasing Arsenic level. With the increasing of As level up to 40 mg As kg^{-1} soil, dry matter content remained more than 20%

Table 4. Effect of Arsenic levels on specific gravity of tuber and dry matter content of tuber flesh and tuber peel

Treatments	Specific gravity ($g\ cm^{-3}$)	Tuber flesh dry matter content (%)	Tuber peel dry matter content (%)
As_0	1.066 a	21.019 a	22.586 ab
As_1	1.064 a	20.72 a	23.34 a
As_2	1.048 b	20.20 ab	22.152b
As_3	1.015 c	19.84 b	21.67 b
CV (%)	1.54	5.08	5.63
LSD (0.05)	0.013	0.866	1.052

In a colums means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. As_0: Control, As_1: 20 mg As kg^{-1} soil, As_2: 40 mg As kg^{-1} soil, As_3: 60 mg As kg^{-1} soil.

Table 5. Effect of rice husk levels on specific gravity of tuber and dry matter percent of tuber flesh and tuber peel

Treatments	Specific gravity ($g\ cm^{-3}$)	Tuber flesh dry matter (%)	Tuber peel dry matter (%)
R_0	1.021 b	19.91 b	21.88
R_1	1.050 a	20.06 b	22.3
R_2	1.058 a	20.27 b	22.56
R_3	1.063 a	21.53 a	23.00
CV (%)	1.54	5.08	5.63
LSD (0.05)	0.013	0.866	NS

In a colums means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. NS= Non-significant, R_0- 0 g rice husk kg^{-1} soil, R_1-20 g rice husk kg^{-1} soil, R_2-40 g rice husk kg^{-1} soil, R_3-60 g rice husk kg^{-1} soil

Table 6. Combined effect of Arsenic and rice husk on specific gravity of tuber and dry matter of tuber flesh and tuber peel

Treatment combinations	Specific gravity ($g\ cm^{-3}$)	Tuber flesh dry matter (%)	Tuber peel dry matter (%)
$As_0 R_0$	1.050 a-e	20.15	22.25
$As_0 R_1$	1.066 a-d	20.97	21.83
As_0R_2	1.075 a	22.35	22.57
As_0R_3	1.072 ab	20.60	23.69
As_1R_0	1.055 a-e	19.37	22.77
As_1R_1	1.065 a-d	20.82	23.38
As_1R_2	1.065 a-d	22.33	23.47
As_1R_3	1.071 a-c	20.34	23.767
As_2R_0	1.031 ef	20.38	21.49
As_2R_1	1.047 b-f	19.463	22.49
As_2R_2	1.047 b-f	21.10	22.430
As_2R_3	1.065 a-d	18.42	22.20
As_3R_0	0.947 g	19.39	21.02
As_3R_1	1.023 f	19.82	21.56
As_3R_2	1.043 d-f	20.35	21.76
As_3R_3	1.044 c-f	21.24	22.35
CV (%)	1.54	5.08	5.63
LSD (0.05)	0.027	NS	NS

In a colums means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. NS= Non-significant, As_0: Control, As_1: 20 mg As kg^{-1} soil, As_2: 40 mg As kg^{-1} soil, As_3: 60 mg As kg^{-1} soil. R_0- 0 g rice husk kg^{-1} soil, R_1-20 g rice husk kg^{-1} soil, R_2-40 g rice husk kg^{-1} soil, R_3-60 g rice husk kg^{-1} soil after that dry matter content decreased (Table 4). Tuber peel dry matter content also decreased with increasing Arsenic levels. A higher concentration of As is toxic to potato plant, it influences the metabolic process, induce phytotoxicity (Haque *et al.*, 2018) and affected different types of plant nutrients especially the phosphate through disrupting of phosphate metabolism, which ultimately reduced the uptake of P in a plant (Farnese *et al.*, 2014). But P is essential to increase the percentage of dry matter of potato (Fernandes *et al.*, 2015). As a result, when rice husk levels were increased, the accumulation of Arsenic was decreased in plant and increased tuber dry matter content by up taking more P in a plant. For different rice husk levels, dry matter content of tuber flesh was observed significant result but not on tuber peel (Table 5). The results showed that flesh dry matter content gradually increased with increasing rice husk level. The combination of As and rice husk had no significant effect on tuber flesh and peel dry matter (Table 6). Numerically the highest dry matter content was recorded in As_1R_2 (22.33%) where the lowest was in As_2R_3 (18.42%) (Table 6).

CONCLUSION

Rice husk had significant effects on yield and quality contributing parameters of potato. Rice husk increased yield and improved the quality characters of potato tuber, like slightly increased dry matter content and specific gravity, it also removed Arsenic load from tuber flesh and peel. The soil treated with 60 g Rice husk kg^{-1} soil, decreased 67.51% and 66.73% Arsenic accumulation through tuber flesh and peel, respectively, compared to without rice husk. Among the treatment combinations, although As_1R_1, As_1R_2 and As_1R_3 were suitable but As_1R_1 was the appropriate because, in this combination, tuber flesh accumulated 0.123 mg As kg^{-1} FW which is still lesser than the critical level of As contamination (0.15 mg kg^{-1} FW, So, Potato growers can cultivate potato up to 20 mg kg^{-1} As contaminated soil using 20 g rice husk kg^{-1} soil. Potato production in this condition is safe for human consumption. Since As content in tuber reduced with increasing the rice husk levels, the experiments opens new door for further research to find out another bio-adsorbents to minimize more than 80% of As load from potato tubers.

Acknowledgements

The authors are grateful to Sher-e-Bangla Agricultural University Research System (SAURES) for funding this study.

REFERENCES

Abedin, M.J., Feldmann, J. and Meharg, A.A. 2000. Uptake Kinetics of Arsenic Species in Rice Plants. *Pl. Physiol.,* 128: 1120-1128.

Brown, C.R. 2005. Antioxidants in potato. *Amer. J. Potato Res*., 82: 163-172.

Carbonell-Barrachina, A.A., Burlo, E., Burgos-Hernandez, A., Lopez, E. and Mataix, J. 1997. The influence of arsenic concentration on arsenic accumulation in tomato and bean plants. *Sci. Hort.,* 71: 167-176.

Das, H.K., Mitra, A.K., Sengupta, P.K., Hossain, A., Islam, F. and Rabbani, G.H. 2004. Arsenic concentrations in rice, vegetables and fish in Bangladesh: a preliminary study. *Environ. Intl*., 30: 383-387.

Duxbury, J.M., Mayer, A.B., Lauren, J.G. and Hassan, N. 2003. Food chain aspects of arsenic contamination in Bangladesh: Effects on quality and productivity of rice. *J. Environ. Sci. Health.,* 38: 61-69.

Ducsay, L. 2000. The influence of phytotoxic effects of As, Cd, Pb on production of biomas, their accumulation and chlorophyll. Acta III. Int. Conf. Inorganic substances in living environment, SPU, Nitra: 34-38.

FAOSTAT (FAO, Statistics Division) 2019. Statistical Database. Food and Agricultural Organization of the United Nations, Rome, Italy.

Farnese, F.S., Oliveira, J.A., Farnese, M.S., Gusman, G.S., Silveira, N.M. and Siman, L.I. 2014. Uptake arsenic by plants: Effects on mineral nutrition, growth and antioxidant capacity. Idesia (Arica) 32: 99-106.

Fernandes, A.M., Soratto, R.P., de Aguila Moreno, L. and Evangelista, R.M. 2015. Effect of phosphorus nutrition on quality of fresh tuber of potato cultivars. *Bragantia.,* 74: 102-109.

Freeman, K, L., Franz, P.R and Jong, R.W. 1998. Effect of phosphorus on the yield, quality and petiolar phosphorus concentrations of potatoes (cv. Russet Burbank and Kennebec) grown in the krasnozem and duplex soils of Victoria. *Aust J. Exp. Agricu.,* 38: 83-93.

Gomez, K.A and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research. Wiley Inter-Science Publication, New York, 680 P.

Haque, M.N., Ali, M.H. and Roy, T.S. 2018. Specific Gravity, Dry Matter and Starch Concentration of Different Potato Cultivars as Affected by Arsenic Contamination. *Potato Res.,* 61: 51-64.

Hussain, M.A. 2012. Growth, yield and quality of potato as affected by arsenic levels. M.S. Thesis. Department of agronomy. Faculty of Agriculture. Sher-e-Bangla Agricultural University, Dhaka. Bangladesh.

Jacobs, L.W., Keeney, D.R. and Walsh, L.M. 1970. Arsenic residue toxicity to vegetable crops grown on Plainfield sand. *Agron. J.,* 62: 588-591.

Lee, H.Y., Jeon, C., Lim, K.J., Hong, K.C., Lim, J.E., Choi, B.S., Kim, N.W., Yang, J.E. and Ok, Y.S. 2009. Adsorption Characteristics of Heavy Metal Ions onto Chemically Modified Rice Husk and Sawdust from Aqueous Solutions. *Korean J. Environ. Agric.,* 28: 158-164.

Lee, S.S., Lim, J.E., El-Azeem, S.A.M.A., Choi, B., Oh, S.E., Moon, D.H. and Ok, Y.S. 2013. Heavy metal immobilization in soil near abandoned mines using eggshell waste and rapeseed residue. *Environ. Sci. Pollut. Res.,* 20: 1719-1726.

Mondal, M.R.I., Islam, M.S., Jalil, M.A.B., Rahman, M.M., Alam, M.S. and Rahman, M.H.H. 2011. KRISHI PROJUKTI HATBOI (Handbook of Agro-technology), 5th edn. Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh. 307p.