Response of Potato to Ash as an Alternative Source of Potassic Fertilizer

M. M. Rahman[1], M. A. Kader[1], A. Z. M. Moslehuddin[1], M. M. Hasan[2*], A. B. Siddique[1] , S. M. Shamsuzzaman[3] and A. W. Samsuri[4]

[1]Department of Soil Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.
[2]Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400, UPM Serdang, Selangor, Malaysia,
[3]Soil Resource Development Institute, Dhaka-1215, Bangladesh.
[4]Department of Land Management, University Putra Malaysia, 43400UPM Serdang, Selangor, Malaysia
Corresponding author: samsuri@agri.upm.edu.my

Abstract: An experiment was carried out during rabi season of 2011-2012 in the experimental field of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh. The objectives of present research work was to evaluate ash as an alternative source of potassic fertilizer for potato cultivation. The treatment combinations were i) Control (No K), ii) 100% K of recommended dose from muriate of potash (MoP), iii) 75% K from MoP+ 25% K from ash, iv) 50% K from MoP + 50% K from ash, v) 25% K from MoP + 75% K from ash, and vi) 100% K from ash. The result of the experiment indicated that various combinations of ash and MoP influenced the yield, yield contributing characters (length of the tubers, breadth of the tubers, number of tubers per hill, weight of tubers per hill, weight of ten tubers and gross yield of tubers per plot), K content of po tato as well as weed infestation. Among the treatments the highest yield was obtained from 50% K from MoP + 50% from ash (T_3) treated plot. The K content in the potato tuber and weed infestation was also highest for that plot. Considering the yield contributing parameters, yield and number of weeds the T_3 (50% K from MoP + 50% K from ash) treatment was found more suitable than others.

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Key words: Ash, potassic fertilizer, alternative source, potato yield, K content

1. Introduction

Potato (*Solanum tuberosum* L.) is used as a staple food in many countries of the world, but mainly as a vegetable in Bangladesh (Hussain, 1995). It contributes alone as much as 54% of the total annual vegetable production of this country (BBS, 1997). Today, the potato has become a highly successful winter crop in Bangladesh next to the rice. In 2011, Bangladeshi farmers harvested 8.32 million tones of potatoes (24 times more than in 1961), which placed the country at No. 14 among the world's potato producers and No. 4 in Asia (Potato World, 2008). The yield of it is quite low in comparison to that of leading potato growing countries of the world such as 44.7 t ha^{-1} in Netherlands, 43.2 t ha^{-1} in France, 42.3 t ha^{-1} in Germany and Belgium, 40.5 t ha^{-1} in United Kingdom (FAOSTAT, 2008). The main reasons for such a low yield of potato in Bangladesh are use of low quality seed, application of improper amount of manures and fertilizers and use of traditional methods of cultivation. Among the stated reasons non-judicious application of manures and fertilizers is considered as one of the main factors for the poor yield of potato in Bangladesh. Potassium is one of the important macro elements. It is required for plants in large amounts than other major elements. It is also very important as it accelerates tuber development. Abou-Hussein (2005) studied that increasing rate of K increased the fresh and dry weights of haulm of potato and plants supplied with the highest K rate recorded the highest number of tubers/m^2, tuber weight and yield. But the application rate of potassic fertilizer is very high and the whole amount of country demand is fulfilled by import from foreign countries. In this situation ash can be the alternate source of potassic fertilizer and it is very common in our country. Yeledhalli *et al.* (2001) investigated that application of fly ash (FA) at 30 t ha^{-1} or sewage sludge (SS) at 30 t ha^{-1} or recommended dose of NPK fertilizers (RDF) fertilizers improved nutrient use efficiency and the availability of P, K, Ca, Mg, S, Zn and Cu besides improving soil physico-chemical properties and reduced the use of costly chemical fertilizer, bring greater economy in cultivation and minimize environmental pollution. Ashes provide a good source of potassium, calcium, and numerous other trace elements. Hilary (2009) explained that wood ash does have some fertilizer value, the amount varying somewhat with the species of wood being used. Generally, wood ash contains less than 10 percent potash, 1 percent phosphate and trace amounts of micro-nutrients such as iron, manganese, boron, copper

and zinc. The application of ash and K fertilizer increased in soil organic C, N, P, K, Ca and Mg concentrations for improving soil fertility in crop production (Patterson *et al*., 2004; Nottidge *et al*., 2005; Adenawoola and Adejoro, 2005). In spite that, research work on evaluating ash as an alternative source of potassic fertilizer for potato cultivation in Bangladesh is inadequate. Therefore, the main objective of this study was to find out a suitable combination of ash and muriate of potash for economic production of potato.

2. Material and Methods

The experiment was carried out at the Soil Science Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2011 to February, 2012. The experimental area is located at 24075/ N latitude and 90050/ E longitudes at the elevation of 18 m above the sea level. The land of experimental field was medium high, belonging to the Sonatala soil series of Non-calcareous dark grey floodplain soils under the Agro ecological zone (AEZ) of Old Brahmaputra Floodplain and the order Inceptisol.

Table -1. Physical-chemical properties of soil of the experimental plots

Soil properties	Analytical data
Sand	18%
Silt	78%
Clay	4%
Textural class	Silt loam
Soil pH	6.71
CEC(me/100g soil)	15.00
Organic carbon (%)	1.678
Total nitrogen (%)	0.17
Available P (ppm)	10.55
Exchangeable K (meq/100g soil)	0.14
Available S (ppm)	14.25

Treatments and crop culture

One of the most popular potato variety in Bangladesh named "DIMOND" was used as the planting materials in the experiment. The treatments for the present experiment were; i) T_0 = Control (No fertilizer), ii) T_1: 100% K of recommended dose from muriate of potash (MoP), iii) T_2 = 75% K from MoP + 25% K from ash, iv) T_3 = 50% K from MoP + 50% K from ash, v) T_4 = 25% K from MoP +75% K from ash, and vi)T_5 = 100% K from ash.

Table-2. Monthly temperature, rainfall and relative humidity during experimental period

Month	Air temperature (^{0}C)			**Relative humidity (%)	*Rainfall (mm)
	Max.	Min.	Av.		
November 2011	28.75	16.87	22.81	82.23	00.0
December 2011	24.48	13.64	19.06	83.58	00.0
January 2012	23.16	12.43	17.80	80.03	18.0

* means monthly total and ** means monthly average.
Source: Weather Yard, Department of Irrigation and Water Management, Records of Climatological Observations (Monthly), Bangladesh Agricultural University, Mymensingh.

Table-3. Chemical composition of the ash used for the experiment

Parameters	Analytical data
pH	9.1
Organic C (%)	16.0
Nitrogen (%)	1.52
C : N	10.52
Phosphorus (%)	0.76
Potassium (%)	2.8
Calcium (%)	7.6
Magnesium (%)	1.7

The recommended dose of fertilizer was; 120 kg N, 25 kg P, 120 kg K, 12 kg S and 3 kg Zn ha^{-1}.The experiment was laid out in a randomized complete block design with three replications. The size of the unit plot was 4.0 m × 3.0 m. Distances between block to block and plot to plot were 0.5 m. Hill to hill and row to row distances were maintained at 15 cm and 50 cm, respectively. Fertilizers were applied to individual plot according to the treatment and allocated dose. Urea was applied in two equal splits. The half dose of urea and full doses of TSP, MoP, and gypsum were applied in furrows made on both sides of the seed rows and mixed properly with soil at the time of planting. The second split of urea was applied as top dressing at 30 days after planting. Well decomposed cowdung, oil cake and zinc oxide were also applied in all the treatments as Bangladesh Agricultural Research Institute recommended dose 2006 and mixed with soil properly before planting. Healthy, disease free and well sprouted seed tubers were planted on 1st November, 2011 at a depth of 8 cm in furrow maintaining a spacing of 50 cm × 15 cm. Each plot accommodated 25 seed tubers in 6 rows. After planting, the seeds were covered with soil. Only one irrigation was provided throughout the growth period due to low temperature adequate irrigation was not required. The soil was mulched by breaking the crust for an easy aeration and to conserve soil moisture after each irrigation. Earthing up was done three times during the growing period of

potato. The first earthing up was done after 30 days of planting, second one was done after 15 days of first earthing up which was preceded by top dressing of the remaining dose of urea and the third one after 15 days of second earthing up. Ridomil gold@.2% was sprayed three times at an interval of 15 days for preventive measure against late blight disease. Darsbun was applied @ 2 ml L^{-1} water after 25 days of planting to control the cutworm. Spraying the field with Robral@.2%solution for 4-5 times at 7-10 days interval for protecting field against early blight of potato. Potato was harvested after 85 days of planting. The Common symptom of mature potato plant was indicated by the plants showing 80-90% of leaf senescence and the tops started drying. Harvested potato was collected plot-wise and it's followed by local method. Care was taken to avoid injury in potatoes during harvesting.

Data Collection

The number and weight of tubers per hill was recorded after harvesting of 10 sample plants from each unit plot and the average number of tubers was calculated. Ten tubers were collected from each treatment randomly and its average length and breadth were recorded in cm. The number of weed in each plot measured on per square meter. The yield per plot was recorded from harvested tubers of all plants including sample plants of a unit plot. The weeding was done after 3 weeks and 7 weeks of planting of seed tubers. The number of weed in each plot measured on per square meter.

Soil analysis

Initial soil sample was collected from 0-15cm depth before land preparation. The samples were air dried ground, mixed thoroughly and sieved through 10-mm mesh sieve. The composite soil sample was stored in a clean plastic box for physical and chemical analysis. Particle size analysis was done by hydrometer method (Black, 1965) and the textural class was determined by plotting of values for % sand, % silt and % clay on the Marshall's triangular coordinate following the USDA system. The soil pH was measured with the help of a glass electrode pH meter using soil water suspension ratio of 1: 2.5 as described by Jackson (1962). Organic carbon was determined by wet oxidation method (Walkey and Black, 1965). To obtain the organic matter content the amount of organic carbon was multiplied by Van Bemmelen factor 1.73. The results were expressed in percentage (Page *et al.,* 1989). Exchangeable potassium was extracted from the soil with 1.0 N NH_40Ac (pH 7) and K was determined from the extract by flame photometer (Black, 1995).

Preparation and chemical analysis of organic amendments

The ash used for the study was collected from a rice mill and was sieved with 2-mm sieve before application. Small samples from the ash used for the study were taken for laboratory analysis to determine their nutrient compositions. The samples were analysed for organic C, N, P, K, Ca and Mg as described by Okalebo et al. (1993).

Chemical analysis of tuber

The representative potato samples were cut slicesly and dried in an oven at 65°C for about 24 hours and then they were ground by a grinding machine. The prepared samples were then stored in paper bags and finally they were kept into desiccators until analysis. For analysis 0.5g sample was transferred into dry clean 100 ml Kjeldahl flasks. 10 ml of diacid mixture (HNO_3:$HCl0_4$ = 2:1) was added into the flasks. After leaving for a while the flasks were heated slowly at a temperature of 120°C for 45 min. and then 45 min. at 180°C temperature. The contents of the flasks were boiled until they became sufficiently clear and colorless. After cooling the digests were transferred into 50m1 volumetric flasks and the volumes were made up to the mark with distilled water. The digests were used for the determination of K. 5 ml of digest samples for the tuber was taken and diluted to 50 ml volume. The absorbance was measured by atomic absorption flame photometer.

Statistical Analysis

The collected data were analyzed statically by F- test to examine the treatment effect and the mean differences were adjusted by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) and ranking was indicated by letters.

3. Results and Discussion

Average length and breadth of the tubers, number of tubers per hill, weight of tubers per hill and weight of ten tubers were significantly influenced by different treatment combinations (Table-4.). The highest average length (5.68 cm) of tubers was recorded in T_3 (50% K from MoP + 50% K from ash) treatment, followed by T_1 (100% K from MoP), T_2 (75% K from MoP + 25% K from ash), T_4 (25% K from MoP +75% K from ash), and T_5 (100% K from ash) treatment. In contrast, the shortest tubers (4.8 cm) produced in control plot (T_0). The highest average breath of tubers (4.32a) was recorded in T_2 (75% K from MoP + 25% K from ash) and T_3 (50% K from MoP + 50% K from ash) treatment followed by T_1, T_4 and T_5 treatment. Treatments T_2 and T_3 were statistically similar and superior than other treatments. In control

(T_0) treatment had the shortest breath of tubers (3.52cm). Ayub *et al*., (2011) observed that potassium out of macronutrients is very important for potato plant, as it regulates growth and vigour, improves quality and general health that ultimately hastens yield. Potassium also keeps potato away from various physiological disorder and infections. The maximum number of tubers (6.04) per hill was recorded in T_3 (50% K from MoP + 50% K from ash) followed by T_1 (100% K from MoP), T_2 (75% K from MoP + 25% K from ash), T_4 (25% K from MoP +75% K from ash) and T_5 (100% K from ash) treatment. In contrast, minimum number of tubers (3.80) per plant were recorded in control (T_0) treatment. Ayub *et al.,* (2011) found that number of tubers per plant and number of compound leaves per plant significantly affected by the combination of 1/2 Murate of potash and 1/2 FYM. The maximum weight of tubers (168.1g) per hill was recorded in T_3 followed by T_1, T_2, T_4 and T_5 treatment. Treatment T_1, T_2, T_3, T_4 and T_5 were statistically similar and superior than control (T_0) treatment. So minimum weight of tubers (97.1g) per hill was recorded in control (T_0) treatment. The highest weight of ten tubers were recorded in T_3 were followed by T_1, T_2, T_4, and T_5 treatments by T_1, T_2, T_4, and T_5 treatments.

Table-4. Effect of different treatment combination on morphological characters and yield attributes of modern potato variety "dimond"

Treatment	Average length of tubers (cm)	Average breath of tubers (cm)	Number of tubers per hill^{-1}	Weight of tuber g hill^{-1}	Weight of ten tubers (kg)	Gross yield of tubers tha^{-1}
T_0	4.80 c	3.52c	3.80c	97.14b	0.35c	9.71c
T_1	5.23 abc	3.98abc	3.56c	151.90a	0.35c	15.19b
T_2	5.13 bc	4.32a	5.47ab	157.60a	0.42bc	15.75b
T_3	5.68 a	4.32a	6.04a	174.00a	0.59a	17.40a
T_4	5.42 ab	4.10ab	5.18ab	168.10a	0.51ab	16.07ab
T_5	5.05 bc	3.73bc	4.43c	160.50a	0.42bc	16.04ab
CV (%)	5.09	7.40	21.39	16.93	18.06	11.51
F-test	*	*	**	*	*	**

T_0 = Control (No fertilizer), T_1 = 100% K of recommended dose from muriate of potash (MoP), T_2 = 75% K from MoP + 25% K from ash, T_3=50% K from MoP + 50% K from ash, T_4=25% K from MoP +75% K from ash, and T_5=100% K from ash. In a column, means followed by same letter (s) do not differ significantly at 5% level by DMRT; *, ** significant at 5% and 1% levels of probability respectively; CV (%) = Coefficient of variation.

In contrast, lowest weight of ten tubers (0.35 kg) were recorded in T_0 (control). Bansal and Imas (1999) found that some of the tuber quality parameters affected by potassium nutrition are: tuber size, percentage of dry matter, starch content, internal blackening, storability and resistance to mechanical damage. Singh (1999) carried out that potassium application increased percentage of large tubers from 29% (0 kg K_2O/ha) up to 40% (75 kg K_2O/ha) and further up to 44% (150 kg K_2O/ha). The tuber yield increased in average by 10% (75 kg K_2O/ha) and by 33% (150 kg K_2O/ha) as compared with control K treatment. This result indicates that sources of potassium have significant effect on average breath, average length of tubers, number of tubers per hill, weight of tubers per hill, and weight of ten tubers of modern potato variety "dimond".

Gross yield of tubers per hectare

Gross yield of tubers was low due to germination loss, local climatic condition and soil. The gross yield of tubers per hectare was significantly influenced by different treatment combinations (Table-4). The maximum yield of tubers (17.39 t ha^{-1}) was recorded in T_3 (50% K from MoP + 50% K from ash) treatment followed by T_4 (25% K from MoP +75% K from ash)) and T_5 (100% K from ash) treatment. The second highest yield of potato (15.75 t ha-1) was obtained from T_2 (75% K from MoP + 25% K from ash) which was statistically similar to T_1 (100% K of recommended dose from muriate of potash) treatment. In contrast, minimum yield of tubers (9.713 t ha^{-1}) per hectare was obtained from control (T_0). This result indicates that source of potassium has excellent effect on gross yield of tubers per hectare of modern potato variety "dimond". Donnelly *et al.* (2006) investigated that frond ash increased yield of 45-65 mm tubers by 76% compared to the control (no ash). The addition of litter ash increased the yield of 45-65 mm tubers by 30%.

Potassium content in tuber

All treatments were statistically different from each other in respect of potassium content in tuber (Table-5). The highest potassium content (1.08%) was

recorded in T_3 (50% K from MoP + 50% K from ash) follows by T_1 (100% RFD of K from MoP), T_2 (75% RFD of K from MoP + 25% RFD of K from ash), T_4 (25% RFD of K from MoP +75% RFD of K from ash T_5 (100% RFD of K from ash) treatment. Ayub *et al.* (2011) observed that potassium out of macronutrients is very important for potato plant, as it regulates growth and vigour, improves quality and general health that ultimately hastens yield. Potassium also keeps potato away from various physiological disorder and infections. El-Fakhrani (1998) observed highly significant correlations between shoot and tuber fresh and dry matter yields as well as the total carbohydrate content and amount in the dry matter tubers and the K fertilizer application rate. The optimal K fertilizer level for growth, yield and total carbohydrate and amount were observed at 240 and 360 kg ha^{-1} at the two seasons.

Table-5. Potssium content in potato for different treatments

Treatments	% potassium (K)
T_0: Control	0.84d
T_1: 100% Recommended dose of K from MoP	0.88cd
T_2: 75% K from MoP + 25% K from ash	1.02ab
T_3: 50% K from MoP + 50% K from ash	1.08a
T_4: 25% K from MoP +75% K from ash	0.94bcd
T_5: 100% K from ash	0.97abc
CV (%)	6.65
F-test	**
In a column, means followed by same letter (s) do not differ significantly at 5% level by DMRT; *, ** significant at 5% and 1% levels of probability respectively; CV (%) = Coefficient of variation; RFD = Recommended fertilizer dose; K = Potassium	

Weed infestation

Number of weeds was significantly influenced by different treatment combinations (Table 6.). The maximum number of weed (185) per square meter was recorded in T_5 (100% K from ash) followed by T_1 (100% K from MoP), T_2 (75% K from MoP + 25% K from ash), T_3 (50% K from MoP + 50% K from ash), T_4 (25% K from MoP +75% K from ash) treatment (104) and T_0 (control) treatment. The lowest number (20) recorded in control (T_0). This data indicates that source of high potassium content increases the number of weed in field. Gana (2009) showed that plots treated with combined application of cattle manure with inorganic fertilizers at all rates gave better performance of weeds, growth parameters and yield than plots treated with separate application of 10 t ha^{-1} cattle manure and 120 kg N -26 kg P-37 kg K ha^{-1} through inorganic fertilizer.

Table-6. Number of weed for different treatments

Treatments	No of weed m^{-2}
T_0: Control	20e
T_1: 100% Recommended dose of K from MoP	43c
T_2: 75% K from MoP + 25% K from ash	33d
T_3: 50% K from MoP + 50% K from ash	44 c
T_4: 25% K from MoP +75% K from ash	104b
T_5: 100% K from ash	185a
CV (%)	4.13
F-test	**
In a column, means followed by same letter (s) do not differ significantly at 5% level by DMRT; *, ** significant at 5% and 1% levels of probability respectively; CV (%) = Coefficient of variation; RFD = Recommended fertilizer dose; K = Potassium	

4. Conclusion

Various treatments were done with various combinations of ash and MoP. So the potassium content of potato for all treatments was not same. Yield contributing characters like number of tubers per hill, average length of tubers, average breath of tubers, weight of tubers per hill, weight of ten tubers, and the gross yield of tubers per plot were significantly influenced by different treatments. The highest number of tubers per hill, weight of tubers per hill were produced in T_3 (50% K from MoP + 50% K from ash) treated plot and that were lowest in T_0 (control) treatment. The highest potassium content was also recorded in T_3 treatment. But, number of weed increased with the increased of ash application. From the results, it may be concluded that yield of modern potato variety "dimond" was affected by different treatment combinations. Among the treatments, 50% K of recommended dose from MoP + 50% K of recommended dose from ash was the best for optimizing tuber yield of modern potato variety "dimond". So, Ash could be used as organic amendments and be well substituted for expensive and scarce K fertilizer for higher yield of potato.

Corresponding Author:
Dr. Samsuri Abd Wahid
Department of Land Management,
Faculty of Agriculture,
Universiti Putra Malaysia,
Serdang, Selangor, Malaysia
Email: samsuri@agri.upm.edu.my

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