Bangladesh Agron. J. 2016, 19(2): 29-38

CHANGES IN CHEMICAL COMPOSITION OF JUTE SEED AS INFLUENCED BY NITROGEN AND PHOSPHORUS FERTILIZERS

S. M. Mahbub Ali[1*], M. Moynul Haque[2], M. Shahadat Hossain[3], M. M. Hussain[4] and M. N. Islam[5]

[1]Planing, Training & Communication Division, Bangladesh Jute Research Institute, Dhaka
[2]Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur
[3]Agronomy Division, Bangladesh Jute Research Institute, Dhaka
[4]GRS Division, Bangladesh Jute Research Institute, Dhaka
[5]Pest Management Division, Bangladesh Jute Research Institute, Dhaka
[*]Corresponding author: mahbubali70@gmail.com

Keywords: Jute seed, nitrogen, phosphorus, chemical changes

Abstract

The study was conducted to determine the effect of nitrogen (N) and phosphorus (P) fertilizer on the physio-chemical changes in composition of jute seed under applied N and P Tossa jute (S.N.) cv. O-9897 was grown at five levels of nitrogen (0, 30, 60, 90 and 120 Kg N ha^{-1}) and five levels phosphorus (0, 10, 20, 30, 40 Kg P ha^{-1}) in late sown condition as seed crop. After harvesting seeds were categorized in to five groups viz. low vigour, medium low vigour, medium vigour, medium high vigour and high vigour which were used for analyzing the chemical composition of jute seed. Results revealed that the chemical composition of jute seed was changed under applied nutrient where combination of 120 kg N $ha^{-1}$and 40 kg P ha^{-1} gave the highest soluble protein, soluble sugar and ash content while the lowest soluble protein, soluble sugar and ash content and the highest free amino acid and oil content were estimated from the treatment with no nitrogen and no phosphorus fertilizer.

Introduction

Jute (*Corchorus* sp.) is the second most important fibre crop after cotton in the world and the main cash crop of Bangladesh On an average 9.00-10.00 lakh tons (44-55 lakh bale) of jute fibre was produced annually from an average area of 4.50–5.00 lakh ha of land in Bangladesh (BBS, 2012). But the area and production was increased significantly from 2010-2011 and onwards. On an average 75-80 lakh bale jute fibre is produced from 7.00-7.50 lakh ha. of land from 2010-11 and onwards due to developing more conscious about environment and stepping forward to the natural fibre by escaping from the perilous impact of synthetic fibre to the environment. As a result demand of jute fibre is being increased in the recent years both in home and abroad. Bangladesh requires about 5000-5500 t of jute seeds every year of which nearly about 12-15% is produced and distributed by the Bangladesh Agricultural Development Corporation and the rest of the seeds are solely produced and utilized by the farmers (Saha, 2011). Traditionally jute seed is produced from fibre crop where seed is sown in the month of March-April and a small portion of crop is kept for seeds at the corner of the field after the harvest of fibre crop. As jute is a short day crop (Kundu *et al.*, 1959), it remains in vegetative phase upto October, the seed crop faces many natural hazards in long staying in the field and produces poor quality seeds (Hossain *et al.,* 1994). This problem, however, solved by adopting the late sown technology of jute seed production where seed is sown in late condition during the month of August-September aiming entirely for seed purpose. Jute seed produced in late sown condition showed unique both in quantity and

qualitative attributes (Hossain *et al.,* 1994). Plant nutrients have tremendous influence on yield and quality of jute seed (Bhttacharjee *et al.,* 2000).

Chemical composition of seed is basically determined by genetic factors and variation in species specifically (Gadgil *et al.*, 1989). However, chemical composition of seed is influenced to some extent by environmental factors and cultural practices. Nitrogen and phosphorus fertilization affect seed yield and physio-chemical characteristics of seed, which may have a major impact on metabolism and subsequent seedling vigour after germination (Sam *et al.,* 1982). Gradual increase in the level of NPK fertilization exerted beneficial effect on growth components, seed yield and seed vigour (Bhattacharjee *et al.,* 2000). In jute seeds, the nature of relationship between applied N and protein content, protein content and seed quality yet to be established.

Chemical composition of jute seed is determined sporadically. Gadgil *et al.,* (1989) determined chemical composition of jute seeds of some *olitorius* and c*apsularis* cultivars and found 11-16% oil content, 16-20% protein and 5-6% ash content. Begum (1997) investigated with two cultivars and four other accessions of *olitorius* jute seed and found 12-13% soluble sugar, 9.50-11.50% lignin, 9-10% hemicelluloses, 14-15% oil content and 9-11% protein. However, the influence of N and P fertilizer on the chemical composition of jute seed and subsequent seed quality has not been investigated elsewhere. Therefore, the present study was conducted aiming to determine the chemical composition of jute seed, to assess the changes in chemical composition of jute seed as influenced by nitrogen and phosphorus fertilizer and to find out the relationship between chemical composition and seed quality of jute.

Materials and Methods

The experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during September 2007 to January 2008. The climate of the experimental site is sub-tropical in nature having very little rainfall in the mid October and mid November with gradual fall in temperature from last week of October. Tossa jute variety O-9897 was used for this experiment. Five levels of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) and five levels of phosphorus (0, 10, 20, 30, 40 kg P ha^{-1}) were used as experimental variables. Nitrogen was used in the form of urea and phosphorus in the form of triple super phosphate. Other fertilizers 20 kg K ha^{-1} as murate of potash and sulphur 20 kg S ha^{-1} as gypsum were used as recommended dose. The design was RCBD with three replications. The unit plot size was 3m x 2.5m. All other cultural practices were maintained according to recommendation. After properly collected dried seeds stored in plastic airtight container for determination of its qualitative parameters and chemical composition at three month of seed storage. Quality of freshly harvested jute seeds were assessed by germination test, speed of germination, seedling evaluation test, mean days to germination, seedling vigour index, electrical conductivity test, accelerated ageing test as per following procedures. Jute seeds were categorized into five groups viz. low vigour, medium low vigour, medium vigour, medium high vigour and high vigour representing N_0P_0, $N_{30}P_{10}$, $N_{60}P_{20}$, $N_{90}P_{30}$ and N_{120} P_{40}, respectively applied in the field. Seeds harvested from these treatment combinations were used for analyzing the chemical composition of jute seed. The seeds were ground with the help of a mini grinding mill and this grounded seed samples were used to determine the chemical composition of seed. The chemical composition of jute seed viz. total soluble protein, total free amino acid, total soluble sugar, oil content and ash content were measured using the following methodology.

Total soluble protein estimation

Seed extracts were prepared according to Kalpana and Madhava (1997) and the total soluble proteins were estimated according to Lowry *et al.* (1951).

Preparation of standard curve protein (Bovine Serum Albumin)

The technical grade of Bovine Serum Albumin was used to prepare standard curve of protein. Standard protein (Bovine Serum Albumin) solution of different concentration (0, 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 mg/20 ml) were prepared. Following the above procedure, the optical density of that protein solution of known concentration were measured at 660 µm wave length by a spectrophotometer and standard curve were prepared from protein concentration against the optical density found. The standard curve of total soluble protein is shown in Fig. 1.

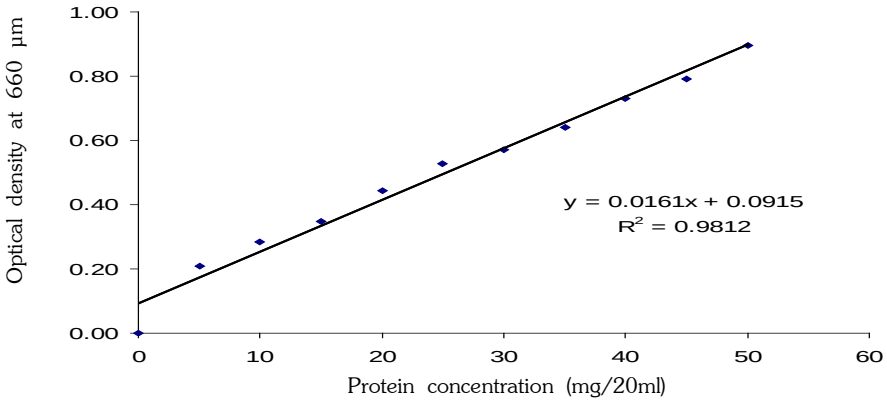

Fig. 1. Standard curve of total soluble protein determination

Total free amino acid estimation

Total free amino acids were estimated according to the method of Moor and Stein (1948).

Preparation of standard curve of amino acid (L-Serine)

The technical grade of L-Serine was used to prepare standard curve of amino acid. Standard amino acid (L-Serine) solution of different concentration (0, 0.50, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 mg/20 ml) were prepared.

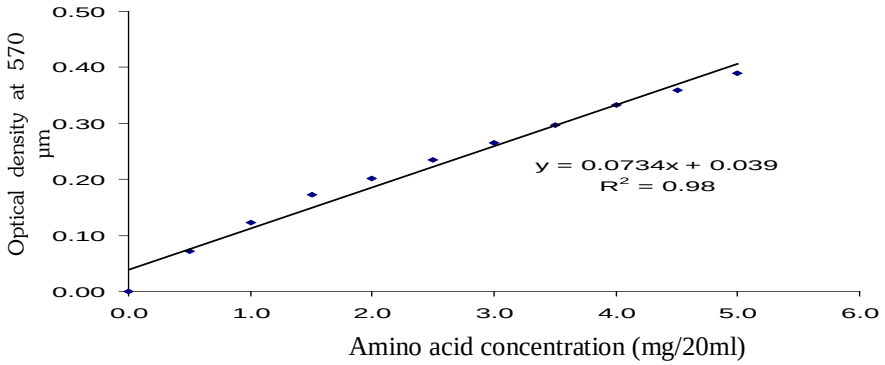

Fig. 2. Standard curve of total free amino acid determination

Following the above procedure, the optical density of that amino acid solution of known concentration were measured at 570 µm wave length by a spectrophotometer and standard curve were prepared of amino acid concentration against the optical density found. The standard curve of total free amino acid is shown in Fig. 2.

Total soluble sugar estimation

Soluble sugar content in the seeds were quantified following anthrone-sulphuric acid method described by Shirlaw and Glchrist (1967).

Preparation of standard curve of sugar (Glucose)

The technical grade glucose was used to prepare standard curve of sugar. Standard sugar (glucose) solution of different concentration (0, 0.25, 0.50, 0.75, 1.00, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75 and 3.00 mg/5 ml) were prepared. Following the above procedure, the optical density of that soluble sugar solution of known concentration were measured at 630 µm wave length by a spectrophotometer and standard curve were prepared of sugar concentration against the optical density found. The standard curve of total soluble sugar is shown in Fig. 3.

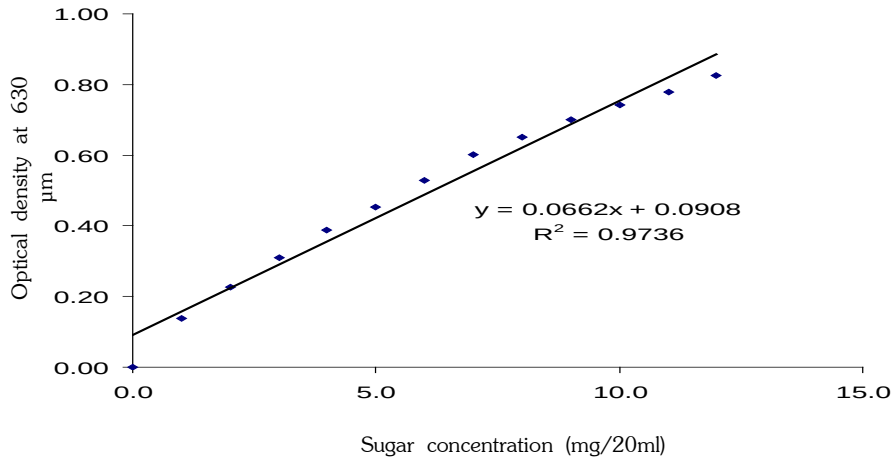

Fig. 3. Standard curve of total soluble sugar determination

Ash content estimation

The ash content of jute seed was determined by heating the oven-dry seeds at 575^{0}C in a muffle furnace until the ash weight were constant (five to six hours) according to Gadgil *et al.* (1989).

Oil content estimation

The oil percentage was estimated Gadgil *et al.* (1989) from moisture-free seed meal by solvent extraction using other petroleum ether (boiling point 60^{0}C to 80^{0}C) in a Soxhlet apparatus for eight hours. The meal was pre-dried (60^{0}C; 24 hours) Two grams of meal was used for the estimation of oil. No further oil was recovered from the residue after eight hours of refluxing.

Statistical analysis

All data were subjected to statistical analysis by analysis of variance (ANOVA) (Gomez and Gomez, 1984). Microsoft EXCEL and MSTAT software programs were used and

the means were compared according to least significant difference (LSD) test. Functional relationships among the parameters were established through correlation and regression analysis.

Results and Discussion

Freshly harvested jute seeds obtained from different doses of nitrogen and phosphorus fertilizers were analyzed to estimate its chemical composition viz. soluble protein, free amino acid, soluble sugar, oil content and ash content. The influence of nitrogen and phosphorus and fertilizers on the chemical composition of jute seed are described below.

Soluble protein

Total soluble protein of freshly harvested jute seed influenced significantly by applied nitrogen and phosphorus fertilizers (Table 1). Total soluble protein increased with the increase of the levels of N and P fertilization. Total soluble protein ranged from 196.30 mg g^{-1} (19.63%) to 224.90 mg g^{-1} (22.49%) which is an agreement with the findings of Gadgil *et al.* (1989) who found 16-20% protein in jute seeds. The highest total soluble protein (224.90 mg g^{-1}) was estimated from the seeds harvested from 120 kg N ha^{-1} and 40 kg P ha^{-1} followed by the treatments 90 kg N ha^{-1} and 30 kg P ha^{-1}. The lowest total soluble protein (196.30 mg g^{-1}) was found from the seeds with no N and P fertilizers. Chakravorty and Singh (1979) also observed that seed protein content increased in cotton seed with increasing N rates. This was because of increased N rates increased N content and subsequently protein content in seeds. As nitrogen is essential component of proteins and related to amino acids, it governs considerable degree in the utilization of nutrients including P (Brady, 1984). Abdel Bagi *et al.* (2002) conducted an experiment with roselle (*Hibiscus sabdariffa* var. *sabdariffa* L.) and reported that nitrogen and phosphorus fertilizers increase the seed protein content which has important implications on seed quality. In present study, there is also positive correlation between the total soluble protein content and germination percentage of jute seed (Fig. 4).

Table 1. Effect of nitrogen and phosphorus fertilizer on total soluble protein of tossa jute seed

Treatment combination	Total soluble protein	
	(mg g^{-1})	Percentage
N_0 P_0	196.30 d	19.63
N_{30} P_{10}	201.30 cd	20.13
N_{60} P_{20}	201.90 c	20.19
N_{90} P_{30}	206.30 b	20.63
N_{120} P_{40}	224.90 a	22.49
$LSD_{(0.05)}$	1.02	-
CV (%)	1.30	-

Means followed by common letter are not significantly different at 0.05 levels by LSD.

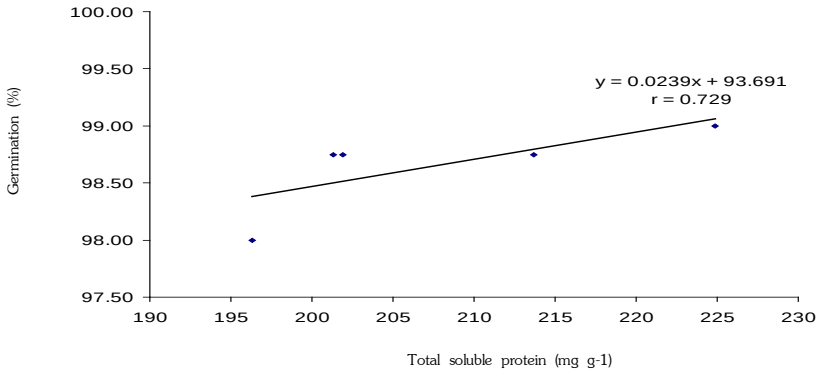

Fig. 4. Relationship between total soluble protein and germination percentage obtained from different level of nitrogen and phosphorus fertilizers

Free amino acid

Total free amino acid of tossa jute seed significantly influenced by the different levels of nitrogen and phosphorus fertilizers (Table 2). In general higher amount of free amino acid was found from the seeds obtained from the treatment with lower level of N and P fertilization and it decreased with the increasing level of N and P fertilizers. The highest total free amino acid (20.99 mg g^{-1}) was estimated from the seeds with no N and P fertilizers and the lowest amino acid content (15.62 mg g^{-1}) was found from the seeds of the treatments with 120 kg N and 40 kg P ha^{-1}. If Table 1 and Table 2 are compared, then it may be seen that free amino acid content was decreased with the increase of total soluble protein. Fig. 5 illustrated the similar scenario that amino acid decreased with the increase of protein in jute seed. Tsai *et al.* (1992) reported that protein content increased from applied nitrogen which was accompanied by an increase in the amount of zein present in the endosperm. Increase in zein content in endosperm reduces the lysine and tryptophan concentrations, thus reducing the total free amino acid. Verma *et al.* (1999) reported that plants take up nitrogen preferably as ammonia and then convert it into glutamine and glutamic acid. These two amino acids act as nitrogen donors for the proline and arginine biosynthesis which reduced the free amino acid and maintained essential amino acid contents in the seed.

Table 2. Effect of nitrogen and phosphorus fertilizer on total free amino acid content of tossa jute seed

Treatment combination	Total free amino acid	
	(mg g^{-1})	Percentage
N_0 P_0	20.99 a	2.10
N_{30} P_{10}	18.81 b	1.88
N_{60} P_{20}	19.08 bc	1.91
N_{90} P_{30}	17.17 d	1.72
N_{120} P_{40}	15.62 e	1.56
LSD (0.05)	0.776	-
CV (%)	2.57	-

Means followed by common letter are not significantly different at 0.05 level by LSD.

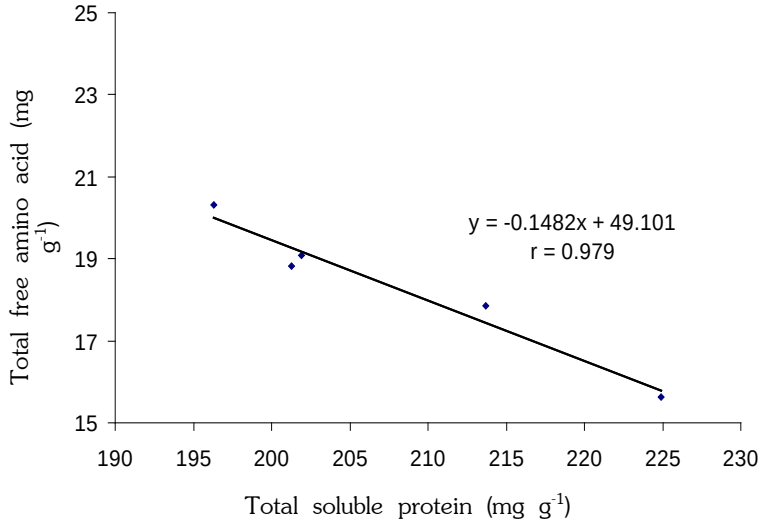

Fig. 5. Relationship between total soluble protein and total free amino acid obtained from different level of nitrogen and phosphorus fertilizers.

Soluble sugar

Total soluble sugar of tossa jute seed influenced profoundly by the application of nitrogen and phosphorus fertilizers (Table 3). Total soluble sugar increased with the increase of the levels of N and P fertilization and it increased from 11.34 to 12.70%. This agrees well to Begum (1997) who found 12-13% soluble sugar from tossa jute seed. The highest total soluble sugar (121.70 mg g^{-1}) was estimated from seeds of the treatments with 120 kg N ha^{-1} and 40 kg P ha^{-1} and it was lowest (113.40 mg g^{-1}) in the treatment without nutrient. In this regard Achakzai and Kayani (2002) reported that total soluble sugar significantly increased with added nitrogen fertilizer in soybean seed. Presence of soluble sugar in seed has great implication on seed quality as there is positive correlation between the total soluble sugar content and germination percentage of jute seed (Fig. 6) which indicated that higher the amount of soluble sugar higher the germination percentage.

Table 3. Nitrogen and phosphorus fertilizer effects on the total soluble sugar content of tossa jute seed.

Treatment combination	Total soluble sugar	
	(mg g^{-1})	Percentage
N_0 P_0	113.40 *e*	11.34
N_{30} P_{10}	115.60 d	11.56
N_{60} P_{20}	117.90 c	11.79
N_{90} P_{30}	119.00 b	11.90
N_{120} P_{40}	121.70 a	12.70
LSD $_{(0.05)}$	0.26	-
CV (%)	1.14	-

Means followed by common letter are not significantly different at 0.05 levels by LSD.

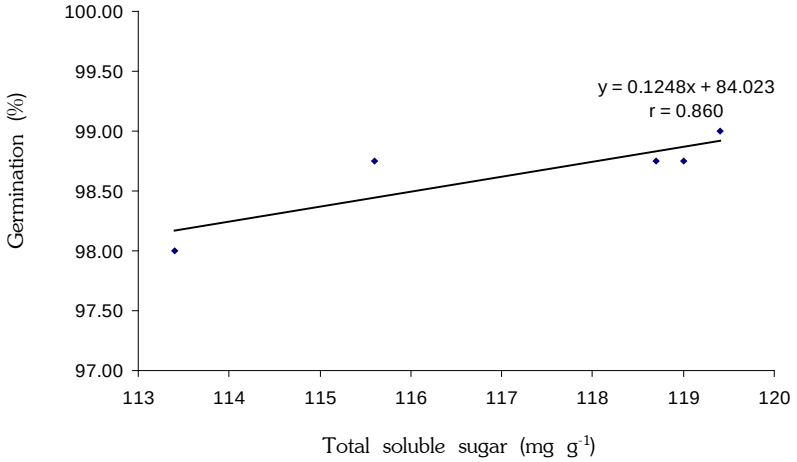

Fig. 6. Relationship between total soluble sugar and germination percentage obtained from different level of nitrogen and phosphorus fertilizers.

Oil content

Oil content of tossa jute seed was also significantly influenced by the different levels of N and P fertilization which ranged from 13.74% to 15.60%. Gadgil *et al.* (1989) found 11-16% and Begum (1997) found 14-15% oil content in tossa jute seed which is almost an agreement with the findings of present study. Increased level of N and P fertilization decreased seed oil content but it was inconsistent (Table 4). The highest oil content (15.60%) was found from the seeds with no N and P fertilizers and the lowest oil content (13.74%) was found from seeds of the treatment with 120 kg N and 40 kg P ha^{-1}. Several investigators observed that nitrogen and phosphorus fertilization affect seed oil content differently in different field crops (Ref.). Cotton seed oil content decreased with the increase of N fertilization (Sam *et al.*, 1982) and P fertilization (Chakravorty and Sing, 1979).

Ash content

Ash content of jute seed varied from 6.12 to 7.24% due to applied N and P fertilization (Table 4). The highest ash content (7.24%) was found from the seeds harvested from the treatment with 120 kg N ha^{-1} and 40 kg P ha^{-1} and it was lowest (6.12%) in seeds with no fertilization. Other treatments contributed intermediate amount of ash content in jute seeds.

Table 4. Effect of nitrogen and phosphorus fertilizer on the oil and ash content of tossa jute seed

Treatment combination	Oil (%)	Ash (%)
N_0 P_0	15.60 a	6.12 c
N_{30} P_{10}	14.50 c	6.73 b
N_{60} P_{20}	14.95 b	6.75 b
N_{90} P_{30}	14.35 d	6.76 b
N_{120} P_{40}	13.74 e	7.24 a
$LSD_{(0.05)}$	0.07	0.05
CV (%)	1.34	1.38

Means followed by common letter are not significantly different at 0.05 levels by LSD.

The amount of ash in jute seed found in present study however differed to that of Gadgil *et al.* (1989) who reported only 5% ash in jute seeds. Higher amount of ash content in seeds of present study might be associated with the increase in thousand seed weight due to applied nutrients as there is positive relationship between thousand seed weight and ash content in jute seed (Fig. 7).

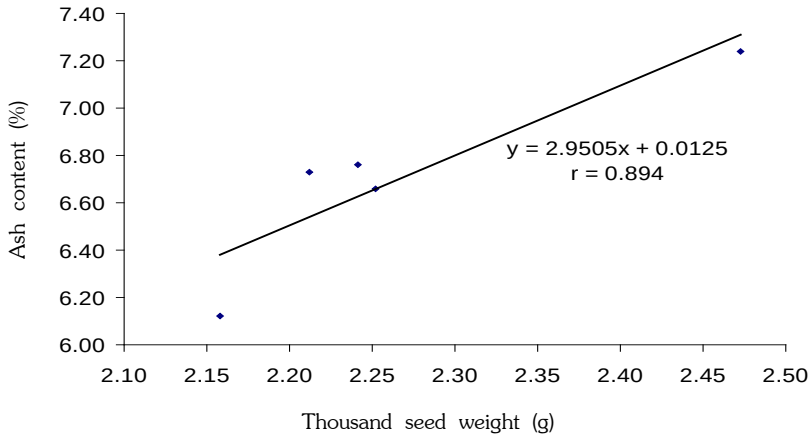

Fig. 7. Relationship between seed weight and ash content obtained from different level of nitrogen and phosphorus fertilizers.

Conclusion

From the study it could be concluded that the chemical composition of jute seed was changed due to applied nutrients, where seeds produced with120 kg N ha^{-1} and 40 kg P ha^{-1} gave the highest soluble protein, soluble sugar and ash content while lowest in free amino acid and oil content. On the other hand, these results affected inversely on seed germination and seed vigour when the treatments had no nitrogen and phosphorus fertilizer.

References

Abdel Bagi, A. A., T. E. M. Hago and F. E. G. Ahmed. 2002. Chemical composition of Roselle (*Hibiscus sabdariffa* var. *Sabdariffa* L.) as affected by genotype and itrogen, Phosphorus and Sulphur fertilization. U. of K. J. Agric. Sci. 10: 1-15.

Achakzai, A. K. K. and S. A. Kayani. 2002. Effect of fertilizer, inoculation and sowing time on chemical composition of field grown soybean seeds. Asian J. Plant Sci. 1: 618-621.

BBS (Bangladesh Bureu of Statistics). 2012. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the Peoples Republic of Bangladesh.

Begum, S. 1997. Physiological and Biochemical studies on the low temperature tolerance in tossa jute (*Corchorus olitorius* L.). Unpublish Ph.D. Thesis, Department of Botany, University of Dhaka. Bangladesh.

Bhattacharjee, A. K., B. N. Mittra and P. C. Mittra. 2000. Seed agronomy of jute. II. Production and quality of *Corchorus olitorius* seed as influenced by nutrient management. Seed Sci. Technol. 28:141-154.

Brady, N. C. 1984. The nature and properties of soils (9th ed.) *McMillan Publishing* Co. Inc. USA.

Chakravorty, S. C. and S. Singh. 1979. Effect of fertilizes (NPK) on seed weight, protein content and oil composition of cotton (*G. hirsutum*). Indian Agric. 23: 165-171.

Gadgil, J. D., K. N. Susseelan, R. Mitra, D. C. Joshua and C. R. Bhatia. 1989. Chemical composition of seed and electrophoretic pattern of seed storage protein of jute *Corchorus olitorius* and *Corchorus capsularius*. Seed Sci. Technol. 17:499-506.

Gomez, K. A. and A. A. Gomez. 1984. Statistical procedure for Agricultural Research. Second edn. John Wiley and Sons. Inc. New York. Pp.304-307.

Hossain, M. A., S. A. Mannan, M. K. Sultana and A. L. Khandakar. 1994. Survey on the constraints of quality jute seed at farm level. Ministry of Agriculture, Agricultural Support Service Project. GOB/World Bank/ODA seed technological research team, Bangladesh Jute Res. Inst. Dhaka. P. 25.

Kalpana, R and K. V. Madhava Rao. 1997. Protein metabolism of seeds of pigeon pea cultivars during accelerated ageing. Seed Sci. Technol. 25: 271-179.

Kundu, B. C., K. C. Basak and P. B. Sarker. 1959. Jute in India. The Indian Central Jute Committee. Pp. 74-136.

Lowry, O. H., N. R. J. Rosebrough, A. L. Farr and R. J. Randail. 1951. Protein measurement with the folin phenol reagent. J. Biol. Chem. 193: 265-275.

Moor, S. and W. H. Stein. 1948. Photometric ninhydrin method for use in the chromatography of amino acid. J. Biol. Chem. 176: 367-387.

Saha, C. K. 2011. Jute Seed Management in Bangladesh. International Seminar on Strengthening of Collaboration for Jute, Kenaf and Allied Fibres Research and Development (held during June 8-9, 2011). International Jute Study Group (IJSG). Pp. 92-97.

Sam. M. J., S. N. Bhola, Y. S. Yadav and A. Prasad. 1982. Response of cotton hybrids to nitrogen and phosphorus. Indian J. Agron. 27: 13-17.

Shirlaw, D. W. and D. W. Grlchrist. 1967. A Practical course in agricultural chemistry. Pergamon Pub. London, U. K. Pp. 122-130.

Tsai, C. Y, I. Dweikat, D. M. Huber and H. L. Warren. 1992. Interrelationship of nitrogen nutrition with maize (*Zea mays*) grain yield, nitrogen use efficiency and grain quality. J. Sci. Food Agric. 58: 1–8.

Verma, D. P. S. and C. S. Zhang. 1999. Regulation of proline and arginine biosynthesis in plants. *In* Plant Amino Acids: Biochemistry and Biotechnology. New York. Pp. 249-265.