INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 9, No. 6, p. 137-144, 2016

RESEARCH PAPER OPEN ACCESS

Estimation of shoot and root biomass with their C, N, P, K and S contents of eight different rice varieties at harvesting stage

Md. Mahmud Hassan*, Musharraf Hossain Mian, G. M. Murshid Alam

Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh

Key words: Biomass, Shoot-root ratios, C-N ratios, Harvesting stage

http://dx.doi.org/10.12692/ijb/9.6.137-144 Article published on December 11, 2016

Abstract

Hybrid hira, Hybrid tia, BRRI dhan28, BRRI dhan29, Binadhan-5, Binadhan-7, Laphadhan and Pijamdhan were grown in a medium high land soil (silt loam, aeric heplaquept) during boro season (crop period: January to June 2011). Shoot and root biomass and their C, N, P, K and S contents at full maturity were determined to assess their potentiality for using as organic residues for the maintenance of soil organic matter. The experiment was laid out in a Randomized Completely Block Design (RCBD) with three replications for each of eight rice varieties having unit plot size 4m×2.5m. Air dry shoot biomass obtained for Hybrid hira, Hybrid tia, BRRI dhan28, BRRI dhan29, Binadhan-5, Binadhan-7, Laphadhan and Pijamdhan were 5.28, 4.82, 4.10, 4.29, 4.98, 3.97, 3.69 and 4.28 t ha^{-1} respectively and root biomass were 1.20, 0.91, 0.99, 1.11, 1.33, 0.78, 0.76 and 0.90 t ha^{-1}, respectively. Organic carbon content in the shoots were 2.97, 2.43, 2.44, 2.54, 2.72, 2.10, 2.04 and 2.73 t ha^{-1}, respectively and roots were 0.52, 0.46, 0.49, 0.51, 0.61, 0.38, 0.40 and 0.41t ha^{-1} respectively. The C-N ratios for the shoots were found to be 150.6, 170.3, 361.0, 268.9, 192.8, 246.8, 203.4 and 315.2; and for the roots were 112.8, 89.7, 114.2, 68.7, 89.4, 108.6, 187.8 and 73.6, respectively. The PKS contents in both shoots and roots also estimate. It may be inferred that both shoot and root residues may play a significant role in organic manuring. Particular attention should be given for assessing the contribution of the root biomass.

* **Corresponding Author:** Md. Mahmud Hassan ✉ mahmud2sana@gmail.com

Introduction

Rice yield, in general, is comparatively lower than that of other South East Asian countries because of poor organic matter management. Organic matter acts as a reservoir of plant nutrients especially N, P, S and micronutrients. Organic fractions also prevent leaching losses of the nutrients. Soil organic C is important in relation to soil quality and ecosystem functioning. A variety of management practices have been developed that can maintain, or possibly increase, crop production and soil organic matter levels. These practices include reduced tillage, the addition of organic amendments, improved crop nutrition and crop rotations that include legumes. Another benefit of increased crop production may be greater sequestration of atmospheric C which in turn may help increase organic matter in soils. Fine roots represent a large fraction of annual primary production in many terrestrial ecosystems and their decomposition rates have important implications for soil organic matter formation (Catherine *et al*., 2010). Cutin and suberin biopolyesters have been suggested to significantly contribute to the stable pool of soil organic matter (Mendez-Millan *et al*., 2010). Rice (Oryza sativa L.) is the leading cereals in the world and staple food crop in Bangladesh. About 20.16% of her total gross domestic production (GDP) comes from agriculture (BBS, 2009). After growing T-aman rice in Kharif season the other crops such as wheat, maize, soybean are grown in Rabi season. Alternatively rice fields are left fallow until the next rice cultivation, during which weeds grow densely. Edible parts are less than half of total rice biomass, and large amounts of 14 plant residues (root and shoot) are left in rice fields in the forms of stubble and rice straw. In addition, organic materials such as compost, green manure and plant residues are applied intentionally to the fields for maintaining soil fertility. The rice field ecosystem, thus, is the ecosystem where production of plant biomass (crops and weeds) and decomposition of plant residues are very active. Rice fields are covered with floodwater during most parts of rice cultivation. Along with the microbial decomposition of plant residues, the plow layer becomes reduced due to the hindrance of fresh air from the atmosphere to the plow layer by the floodwater. Thus, the decomposition of plant residues in rice field ecosystems goes on anaerobically during rice cultivation in summer. The supply and decomposition of organic materials in rice fields are markedly versatile and are closely related to field management. Main sources of organic materials are plant residues (rice, weeds and algae) and rhizodeposition from rice and weed roots. The root biomass automatically left in soils after crop harvest has been playing a significant role in maintaining soil organic matter status and thus soil fertility behind the screen from time immemorial. This has now drawn attention of the scientists working on soil fertility management. More in-depth research is needed to ascertain the contribution of rice roots (as well as rice shoots/straw if applied) in addressing the difficult task of maintaining sustainable soil productivity. Therefore, the present study was planned to test the following objectives.

Objectives:

i. To estimate the root and shoot biomass of eight different rice varieties and

ii. To estimate the C, N, P, K and S contents of root and shoot biomass for assessing their quality as organic sources for manuring at harvesting stage

Materials and methods

The initial soil samples were analyzed for both physical and chemical properties in the laboratory of the Department of Soil Science, Bangladesh Agricultural University, Mymensingh. The properties studied include particle-size analysis, p^H, organic matter content, total N, available P, exchangeable K, available S and cation exchange capacity (CEC). The soil was analyzed following standard methods as follows and data analysis has been done by using MSTAT-C.

Determination of root and shoot biomass at full maturity i.e. harvesting stage

Binadhan-7 was harvested on 24th May, 2011. Hybrid hira, Hybrid tia, BRRI dhan28 and BRRI dhan29 were harvested at maturity on 24^{th} June, 2011. Binadhan-5 and was harvested on 28th June, 2011.

Pijamdhan and Laphadhan were harvested on 30th June, 2011. Each harvested variety was threshed plot-wise. Root and shoot yields were recorded plot-wise and moisture percentage was calculated after sun drying. Dry weight of root was recorded and expressed as t ha^{-1} on oven dry basis. Root samples were preserved for chemical analysis. Dry weight of shoot was recorded and expressed as t ha^{-1} on oven dry basis. Shoot samples were preserved for chemical analysis.

Chemical analysis of plant samples

Organic carbon of the soil was determined by wet oxidation method described by Walkley and Black (1934). The nitrogen in soil was estimated by micro-kjeldahl method. Available phosphorus was extracted from the plant sample by shaking with 0.5 M $NaHCO_3$ solution at p^H 8.5 following the method of Olsen *et al.* (1954). The extracted potassium was determined by using flame photometer and calibrated with a standard K curve (Black, 1965).

Available S content in soil was determined by extracting soil samples with 0.15% $CaCl_2$ solution as described by Page *et al.* (1989).

$$\text{Nutrient content (kg ha}^{-1}) = \frac{\{\text{Nutrient content (\%)} \times \text{Yield (kg ha}^{-1})\}}{100}$$

The analysis of variance was done for the data obtained for shoot and root biomass as well as for the nutrient contents in the biomass following the ANOVA technique and the mean results in case of significant F-value were adjudged by the Duncan's Multiples Range Test (DMRT) (Gomez and Gomez, 1984).

Results and discussion

Root and shoot biomass production (t ha^{-1})

The Binadhan-5 variety (Table 1) gave the highest (1.33 t ha^{-1}) root biomass yield which differed significantly from the root yields of Hybrid tia Binadhan-7, Laphadhan and Pijamdhan. The lowest was obtained for the Laphadhan (0.76 t ha^{-1}).

Table 1. Root and shoot biomass production (t ha^{-1}) by eight different rice varieties at harvesting stage.

Group of variety	Name of the varieties	Biomass production (t ha^{-1})		Total Biomass production (t ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	1.20ab	5.28a	6.48a
	Hybrid tia	0.91de	4.82abc	5.73abc
BRRI	BRRI dhan28	0.99cd	4.10cd	5.09cd
	BRRI dhan29	1.11bc	4.29bcd	5.40abcd
BINA	Binadhan-5	1.33a	4.98ab	6.31ab
	Binadhan-7	0.78e	3.97d	4.75cd
Local	Laphadhan	0.76e	3.69d	4.45d
	Pijamdhan	0.90dc	4.28bcd	5.18bcd
Level of significant		**	**	**
SE (±)		0.08	0.26	0.40
CV (%)		24.46	13.23	18.30

The shoot biomass yields ranged from 5.28 t ha^{-1} (Hybrid hira) to 3.69 t ha^{-1} (Laphadhan).Total biomass produced by the shoots and roots of Hybrid hira, Hybrid tia, BRRI dhan28, BRRI dhan29, Binadhan-5, Binadhan-7, Laphadhan, Pijamdhan varieties were 6.48, 6.48, 5.73, 5.09, 5.40, 6.31, 4.75, 4.45 and 5.18 t ha^{-1} respectively. The highest (6.48 t ha^{-1}) total shoot and root biomass obtained for Hybrid hira did not differ significantly from the total yields produced by Hybrid tia (5.73 t ha^{-1}), BRRI dhan29 (5.40 t ha^{-1}) and Binadhan-5 (6.31 t ha^{-1}).

*Organic carbon content (t ha^{-1}) of root and shoot*The Binadhan-5 roots were found (Table 2) to contain the highest (0.61 t ha^{-1}) amount of organic carbon which differed statistically only from the total organic carbon assimilated in the roots of Binadhan-7 (0.38 t ha^{-1}), Laphadhan (0.40 t ha^{-1}) and pijamdhan (0.41 t ha^{-1}).

The highest shoot organic carbon content (2.97 t ha^{-1}) was recorded for Hybrid hira rice which differed significantly from total shoot carbon content of the shoots of Laphadhan (2.04 t ha^{-1}), Binadhan-7 (2.10 t ha^{-1}) and Pijamdhan (2.37 t ha^{-1}). The highest total root plus shoot organic carbon content (3.49 t ha^{-1}) was recorded for the Hybrid hira which, however, did not differ significantly from the total organic carbon content of Hybrid tia, BRRI dhan28, BRRI dhan29, Binadhan-5 and Pijamdhan. The lowest total organic carbon content (2.44 t ha^{-1}) was recorded for the Laphadhan.

Table 2. Organic carbon content (t ha^{-1}) of shoots and roots of eight different rice varieties at harvesting stage.

Group of variety	Name of the varieties	OC content (t ha^{-1})		Total OC content (t ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	0.52ab	2.97a	3.49a
	Hybrid tia	0.46ab	2.43abc	2.89ab
BRRI	BRRI dhan28	0.49ab	2.44abc	2.93ab
	BRRI dhan29	0.51ab	2.54abc	3.05ab
BINA	Binadhan-5	0.61a	2.72ab	3.33ab
	Binadhan-7	0.38b	2.10c	2.48b
Local	Laphadhan	0.40b	2.04c	2.44b
	Pijamdhan	0.41b	2.37bc	2.78ab
Level of significant		**	*	**
SE (±)		0.05	0.26	0.31
CV (%)		19.44	16.15	16.59

Table 3. Nitrogen content (kg ha^{-1}) by the shoots and roots of eight different rice varieties harvesting stage.

Group of variety	Name of the varieties	Nitrogen content (kg ha^{-1})		Total Phosphorus content (kg ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	4.61cd	19.72a	24.33a
	Hybrid tia	5.13bc	14.27b	19.4bc
BRRI	BRRI dhan28	4.29d	6.76e	11.05d
	BRRI dhan29	7.42a	9.45cd	16.87c
BINA	Binadhan-5	6.82a	14.11b	20.93b
	Binadhan-7	3.50e	8.51cde	12.01d
Local	Laphadhan	2.13f	10.03c	12.16d
	Pijamdhan	5.57b	7.52de	13.09d
Level of significant		**	**	**
SE (±)		0.25	0.68	0.93
CV (%)		33.62	37.69	18.6

Nitrogen content (kg ha^{-1}) of root and shoot

The root N content of eight rice varieties (Table 3) varied from 2.13 kg ha^{-1} to 7.42 kg ha^{-1} (Table 4.3). The highest root N content (7.42 kg ha^{-1}) was found for BRRI dhan29 which was statistically similar to the root N content of Binadhan-5 (6.82 kg ha^{-1}) and they both differed statistically from the root N contents of all the rest varieties.

The lowest root N content (2.13 kg ha^{-1}) was observed for Laphadhan which was statistically different from the root N contents of all the rest seven varieties. The shoot N content varied from 6.76 kg ha^{-1} to 19.72 kg ha^{-1} (Table 3).

The shoots of Hybrid hira contained the highest amount of N (19.72 kg ha^{-1}) which was statistically superior to rest seven varieties.

The lowest shoot N content (6.76 kg ha^{-1}) was recorded for BRRI dhan28 which was statistically identical to the shoot N content of Binadhan-7 (8.51 kg ha^{-1}) and Pijamdhan (7.52 kg ha^{-1}).

The total N content of shoots plus roots of Hybrid hira (24.33 kg ha^{-1}) was the highest and significantly different from the N content of the shoots plus roots of the rest seven varieties. The lowest total N content of roots plus shoots of BRRI dhan28 (11.05 kg ha^{-1})

was found statistically similar to the total N contents of the shoots plus roots of Binadhan-7 (12.01 kg ha^{-1}), Laphadhan (12.16 kg ha^{-1}) and Pijamdhan (13.09 kg ha^{-1}). Many reports on similar findings are also available (Ameta and Singh, 2004).

Table 4. Phosphorus content (kg ha^{-1}) by the shoots and roots of eight different rice varieties at harvesting stage.

Group of variety	Name of the varieties	Phosphorus content (kg ha^{-1})		Total Phosphorus content (kg ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	1.70a	3.65bc	5.35a
	Hybrid tia	0.46cd	3.35d	3.81b
BRRI	BRRI dhan28	0.20d	2.22e	2.42c
	BRRI dhan29	0.82b	1.86f	2.68c
BINA	Binadhan-5	0.66bc	4.07a	4.73a
	Binadhan-7	0.27d	3.71b	3.98b
Local	Laphadhan	0.55c	1.91f	2.46c
	Pijamdhan	0.64bc	3.40cd	4.04b
Level of significant		**	**	**
SE (±)		0.09	0.10	0.23
CV (%)		48.26	28.15	51.42

Phosphorus content (kg ha^{-1}) of root and shoot

The highest root phosphorous content (1.70 kg ha^{-1}) was observed (Table 4) for Hybrid hira which was statistically higher over root P contents of other seven varieties. The lowest root P content was observed for the BRRI dhan28 (0.20 kg ha^{-1}) which did not differ significantly from the root P content of Binadhan-7 (0.27 kg ha^{-1}), Hybrid tia (0.46 kg ha^{-1}.

The second highest root phosphorous content was 0.82 kg ha^{-1} for BRRI dhan29 which was statistically similar to P content of Binadhan-5 (0.66 kg ha^{-1}) and Pijamdhan (0.64 kg ha^{-1}). On the other hand, the highest phosphorous content (4.07 kg ha^{-1}) in shoot was recorded for Binadhan-5 which was statistically different from other seven rice varieties.

Table 5. Potassium content (kg ha^{-1}) by the shoots and roots of eight different rice varieties at harvesting stage.

Group of variety	Name of the varieties	Potassium content (kg ha^{-1})		Total Potassium content (kg ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	4.36a	74.75b	79.11b
	Hybrid tia	2.58b	81.24a	83.82a
BRRI	BRRI dhan28	2.22b	46.19f	48.41e
	BRRI dhan29	2.36b	61.83c	64.19c
BINA	Binadhan-5	2.16b	63.86c	66.02c
	Binadhan-7	1.38c	50.18e	51.56e
Local	Laphadhan	1.35c	55.14d	56.49d
	Pijamdhan	1.91bc	62.75c	64.66c
Level of significant		**	**	**
SE (±)		0.24	1.04	1.28
CV (%)		40.75	18.25	38.63

The lowest shoot phosphorous content (1.86 kg ha^{-1}) was observed for BRRI dhan29 which was statistically similar to shoot P content of Laphadhan (1.91kg ha^{-1}). The second highest shoot phosphorous content (3.71 kg ha^{-1}) was observed for Binadhan-7 which was statistically similar to shoot P content of Hybrid hira (3.65 kg ha^{-1}). The total phosphorous content of roots plus shoots (5.35 kg ha^{-1}) was found for Hybrid hira which was statistically at par with that of Binadhan-5 (4.73 kg ha^{-1}) but significantly different from P contents of other rice varieties.

The lowest total phosphorous content (2.42 kg ha^{-1}) was observed for BRRI dhan28 which was statistically similar to that of BRRI dhan29 (2.68 kg ha^{-1}) and Laphadhan (2.46 kg ha^{-1}).

The second highest total phosphorous content was found for Pijamdhan (4.04 kg ha^{-1}) which was statistically similar to P content of Hybrid tia (3.81 kg ha^{-1}), Binadhan-7 (3.98 kg ha^{-1}).

Jagadeeswari *et al.* (2000) reported that phosphorous uptake significantly increased in straw by the application of manure and fertilizer. Similar findings have been reported by many others (Dongarwar *et al.*, 2003).

Potassium content (kg ha^{-1}) of root and shoot

The highest root potassium content (4.36 kg ha^{-1}) was found (Table 5) for Hybrid hira which was statistically superior to K contents of other seven varieties. The second highest root potassium content (2.58 kg ha^{-1}) was observed for Hybrid tia which did not differ statistically from K contents of Binadhan-5 (2.16 kg ha^{-1}), BRRI dhan28 (2.22 kg ha^{-1}) and BRRI dhan29 (2.36 kg ha^{-1}).

Table 6. Sulphur content (kg ha^{-1}) by the shoots and roots of eight different rice varieties at harvesting stage.

Group of variety	Name of the varieties	Sulphur content (kg ha^{-1})		Total Sulphur content (kg ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	8.99a	29.93a	38.92a
	Hybrid tia	2.34e	24.29b	26.63b
BRRI	BRRI dhan28	2.08e	20.57c	22.65c
	BRRI dhan29	4.19c	9.41e	13.6ef
BINA	Binadhan-5	3.20d	16.27d	19.47d
	Binadhan-7	3.82cd	23.89b	27.71b
Local	Laphadhan	5.63b	9.46e	15.09e
	Pijamdhan	2.32e	9.66e	11.98f
Level of significant		**	**	**
SE (±)		0.26	0.65	0.91
CV (%)		54.66	42.55	43.95

The lowest root potassium content (1.35 kg ha^{-1}) was observed for Laphadhan but remained statistically similar to the K contents of Binadhan-7 (1.38 kg ha^{-1}) and Pijamdhan (1.91 kg ha^{-1}). The highest potassium content (81.24 kg ha^{-1}) in shoots was obtained for Hybrid tia which was statistically superior to K content of other seven varieties. The lowest shoot potassium content (46.19 kg ha^{-1}) was observed for BRRI dhan28 which was statistically lower to K content of other seven varieties. The second highest shoot potassium content (74.75 kg ha^{-1}) was found for Hybrid tia which was statistically higher over the rest six varieties. The shoot potassium content of BRRI dhan29 was 61.83 kg ha^{-1} which was statistically similar to that of Binadhan-5 (63.86 k ha^{-1}) and Pijamdhan (62.75 kg ha^{-1}). The Laphadhan shoot potassium content was 55.14 kg ha^{-1} was statistically different from K content of Binadhan-7 (50.18 kg ha^{-1}). The highest total root plus shoot potassium content (83.82 kg ha^{-1}) was recorded for Hybrid tia which was statistically higher over K contents of other seven varieties. The lowest total potassium content (48.41 kg ha^{-1}) was registered by BRRI dhan28 which was statistically similar to total K content Binadhan-7 (51.56kg ha^{-1}). The second highest root plus shoot potassium content (79.11 kg ha^{-1}) was recorded for Hybrid hira which statistically from K contents of other six varieties. The total potassium content of Pijamdhan was 64.66 kg ha^{-1} which was statistically similar to K content of BRRI dhan29 (64.19 kg ha^{-1}) and Binadhan-5 (66.02 kg ha^{-1}).

Sulphur content (kg ha^{-1}) of root and shoot

The highest root sulphur content (8.99 kg ha^{-1}) was shown (Table 6) by Hybrid hira was statistically higher compared to root S contents of other seven varieties. The lowest root sulphur content (2.08 kg ha^{-1}) was observed for BRRI dhan28 which was statically similar to root S contents of Hybrid tia (2.34 kg ha^{-1}) and Pijamdhan (2.32 kg ha^{-1}).

The highest sulphur content (29.93 kg ha^{-1}) in shoot recorded for Hybrid hira was statistically higher over shoots S contents of other seven varieties. The lowest shoot sulphur content (9.41 kg ha^{-1}) found for BRRI dhan29 was statistically similar to S contents of Pijamdhan (9.66 kg ha^{-1}) and Laphadhan (9.46 kg ha^{-1}).

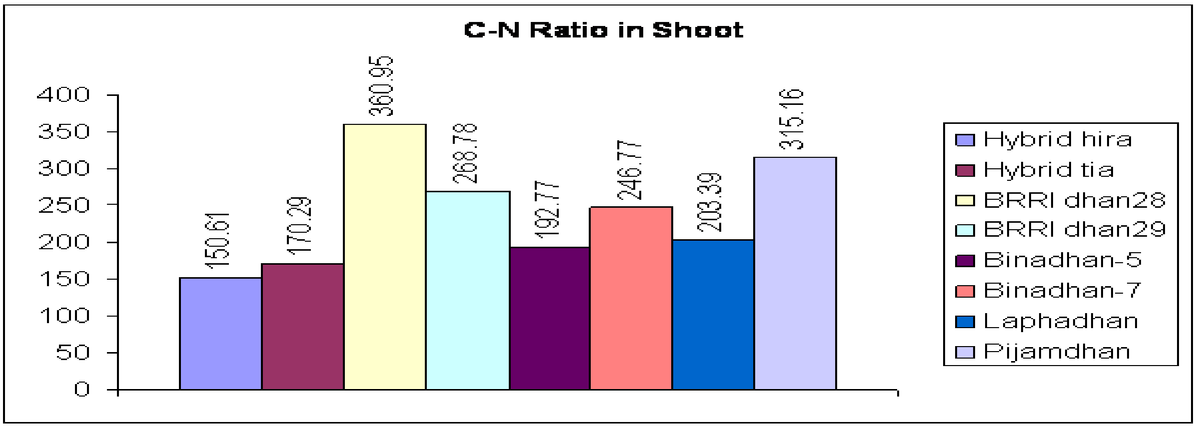

Fig. 1. C-N Ratio in shoot

The highest total root plus shoot sulphur content (38.92 kg ha^{-1}) found for Hybrid hira was statistically higher over total S contents of other seven varieties. The lowest total sulphur content (11.98 kg ha^{-1}) recorded for Pijamdhan was statistically similar to that of BRRI dhan29 (13.6 kg ha^{-1}). Many other similar findings are also available (Sarfaraz *et al.*, 2002).

Carbon-nitrogen ratio

The shoots of BRRI dhan28 registered the highest C-N ratio of 360.95 which was statistically higher over the C-N ratio of other seven rice varieties.

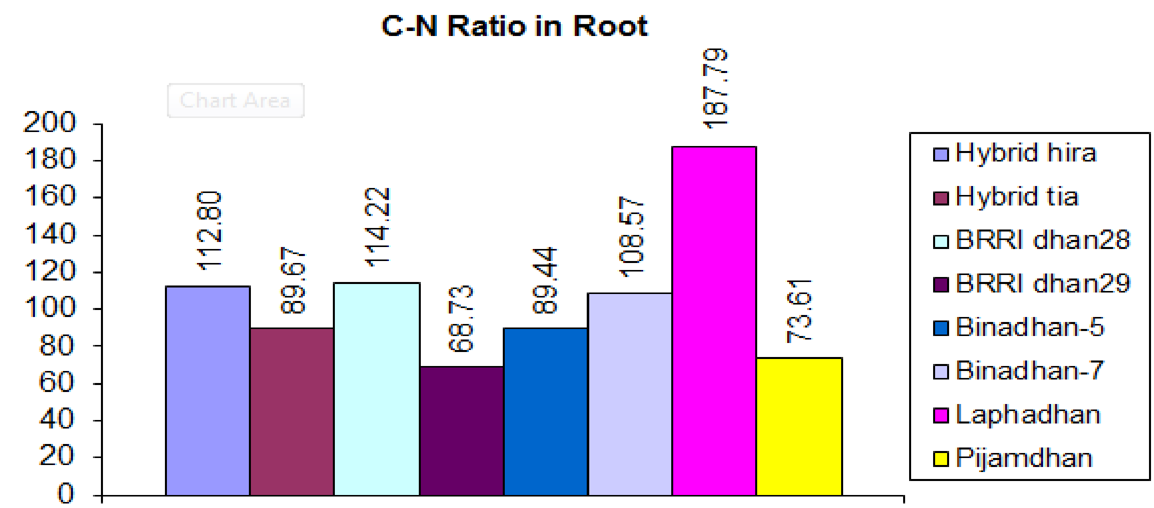

Fig. 2. C-N Ratio in root.

The shoots of Hybrid hira registered the lowest C-N ratio of 150.61 (Fig. 1).

The roots of Laphadhan recorded the higher C-N ratio of 187.79 which was significantly higher over the root C-N ratio of the rest seven rice varieties. The lowest C-N ratio of 68.73 was found for the roots of BRRI dhan29 (Fig. 2).

Conclusion

The present study had the objective of estimating the shoot and root biomass together with their C, N, P, K,S composition both at harvesting stage (full maturity) in order to assess their qualities in quest of adding them into soils as organic residues for addressing the need for maintain and/or augmentation of soil organic matter. But, however, such effects should continue at least for unveiling the actual contribution of rice roots that are left in soils in the maintenance of soil organic matter.

References

Ameta GS, Singh HG. 2004. Comparative efficiency of neem cake coated prilled urea and splitting N application in wheat production. International Tropical Agriculture **8(3)**, 189-192.

BBS. 2009. The Yearbook of Agricultural Statistics of Bangladesh Statistic Division Ministry of Planning, Government of People's Republic of Bangladesh, Dhaka. 129-132 P.

Black CA. 1965. Methods of Soil Analysis. Part I and II American Society of Agronomy. Inc. Publication Madison, Wisconsin, United State of America.

Dongarwar UR, Pantakar MN, Pawar WS. 2003. Response of rice different fertility levels. Journal of Soil and Crops **13(1)**, 102-122.

Gomez KA. 1984. Statistical Procedures for Agricultural Research. Second. John Wiley and Sons. New York. 207-215 P.

Oslen SR, Cole CV, Watanable FS, Dean LA. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United State. Depertment of Agriculture. Cire. 929.

Page AL, Miller RH, Keeney DR. 1989. Methods of Soil Analysis, Part-II (Second Edition). American Society of Agronomy, Inc., Publication, Madison, Wisconsin. United State of America. 501-534 P.

Sarfaraz M, Mehdi, Sadic SM, Hassan G. 2002. Effects of Sulphur on yield and chemical composition of rice .Sarhad Journal of Agriculture **18**, 411- 414.

Walkey A, Black IA. 1934. An experiment of degtiareff method for determining soils organic matter and proposed modification for the chronic acid titration method. Soil Science **37,** 29-38.