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

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

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 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 for Hybrid hira, Hybrid tia, BRRI dhan28, BRRI dhan29, Binadhan-5, Binadhan-7, Laphadhan and Pijamdhan were 6.04, 5.44, 5.34, 5.20, 4.02, 4.99, 4.53 and 5.16 t ha^{-1} and root biomass of 2.54, 1.21, 1.28, 1.77, 1.74, 1.75, 1.02 and 1.39 t ha^{-1}. Organic carbon content in the shoots were 3.38, 2.85, 2.93, 2.92, 2.10, 2.63, 2.39 and 2.72 t ha^{-1} and roots were 1.36, 0.60, 0.67, 0.82, 0.82, 0.78, 0.55 and 0.55 t ha^{-1} respectively. The C-N ratios for the shoots were found to be 98.5, 67.7, 88.9, 91.6, 145.6, 62.7, 85.9 and 104.0; and for the roots were 106.6, 99, 77.9, 98.4, 98.2, 66.3, 138.5 and 122.7, 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 in this regard.

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Introduction

Rice is the staple food for more than 3.5 billion people worldwide, around half of the world's population. Rice is the staple food in Asia, where 600 million people live in extreme poverty. For these people, nearly all of whom eat rice two or three times a day, it can contribute 30% to 70% of their calorie intake. Rice consumption is increasing, and demand for rice will outstrip supply if production does not increase faster than its current rate. This means we have to produce even more rice. So, rice varieties must have higher yield potential and crop management techniques have to help achieve this potential. With a sufficiently high and reliable supply of rice, prices are more likely to stay affordable and consistent, which is important for poor rice consumers.

In Bangladesh, food security has been and will remain a major concern because food requirement is increasing at an alarming rate due to increasing population. Projected supply and demand balance showed that the country will require 34-35 million tons of food grain by the year 2020 while the supply would be 27-33 million tons (Shahabuddin *et al.,* 1999). Maintenance of desirable organic matter status for obtaining better yields would be vital to combat the challenge of increasing food production. 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 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. This study conducted to estimate of shoot and root biomass with their C N P K and S contents at vegetative 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, pH, 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

Five hills were randomly selected from each plot for recording shoot and root biomass at 72 days after transplanting. Root and shoot were separated after air 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

Plant samples collected from the field experiment were analyzed for N content. Root and straw samples were dried in an oven at 650C for 72 hours and then ground in a grinding mill to pass through a 2-mm sieve. The ground plant materials were stored in small paper bags and placed in desiccators. The samples were analyzed for the determination of N.

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 pH 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).

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

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})

Hybrid hira, Hybrid tia, BRRI dhan28, BRRI dhan29, Binadhan-5, Binadhan-7, Laphadhan, Pijamdhan varieties produced 2.54, 1.21, 1.28, 1.77, 1.74, 1.75, 1.02 and 1.39 t ha^{-1} root biomass, respectively (Table 1).

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

Group of variety	Name of the varieties	Biomass production (t ha^{-1})		Total Biomass production (t ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	2.54a	6.04a	8.58a
	Hybrid tia	1.21cd	5.44ab	6.65bc
BRRI	BRRI dhan28	1.28cd	5.34b	6.62bc
	BRRI dhan29	1.77b	5.20b	6.97b
BINA	Binadhan-5	1.74b	4.02d	5.76cd
	Binadhan-7	1.75b	4.99bc	6.74b
Local	Laphadhan	1.02d	4.53cd	5.55d
	Pijamdhan	1.39c	5.16bc	6.55bc
Level of significant		**	**	**
SE (±)		0.10	0.22	0.32
CV (%)		29.76	12.16	15.50

The highest root biomass (2.54 t ha^{-1}) produced by the variety Hybrid hira differed significantly from the root yields of all other seven varieties. The shoot biomass yields ranged from 6.04 t ha^{-1}(Hybrid hira) to 4.02 t ha^{-1}(Binadhan-5).

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 8.58, 6.65, 6.62, 6.97, 5.76, 6.74, 5.55 and 6.55 tha^{-1}. Total biomass yields of different varieties differed significantly where Hybrid hira produced the highest (8.85 t ha^{-1}) which was statistically superior to the total biomass yields of other varieties.

Root and shoot ratio

The highest shoot t root of 4.5 recorded for the variety Hybrid tia did not differ significantly from the ratios obtained for Laphadhan (4.44), BRRI dhan28 (4.17) and Pijamdhan (3.71). The lowest shoot and root ratio of 2.31 (Binadhan-5) remained statistically similar to the ratio shown by the Hybrid hira (2.38), BRRI dhan29 (2.94) and Binadhan-7 (2.85) represented at Fig. 1.

Organic carbon content (t ha^{-1}) of root and shoot

Hybrid hira rice roots contained the highest (1.36 t ha^{-1}) amount of organic carbon and the Laphadhan roots contained the lowest (0.55t ha^{-1}) amount of organic carbon (Table 2). Total root carbon contained of Hybrid hira rice significantly differed from the total carbon contents of the roots of rest seven rice varieties.

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

Group of variety	Name of the varieties	OC content (t ha^{-1})		Total OC content (t ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	1.36a	3.38a	4.74a
	Hybrid tia	0.60d	2.85bc	3.45bcd
BRRI	BRRI dhan28	0.67cd	2.93ab	3.60bc
	BRRI dhan29	0.82b	2.92ab	3.74b
BINA	Binadhan-5	0.82b	2.10d	2.92d
	Binadhan-7	0.78bc	2.63bc	3.41bcd
Local	Laphadhan	0.55d	2.39cd	2.94cd
	Pijamdhan	0.67cd	2.72bc	3.39bcd
Level of significant		**	**	**
SE (±)		0.06	0.17	0.23
CV (%)		32.04	14.60	20.64

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

Group of variety	Name of the varieties	Nitrogen content (kg ha^{-1})		Total Nitrogen content (kg ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	12.80a	34.31b	47.11b
	Hybrid tia	6.06d	42.13a	48.19b
BRRI	BRRI dhan28	8.60c	32.95bc	41.55c
	BRRI dhan29	8.33c	31.87c	40.2c
BINA	Binadhan-5	8.35c	14.42e	22.77e
	Binadhan-7	11.76b	41.98a	53.74a
Local	Laphadhan	3.97e	27.84d	31.81d
	Pijamdhan	5.46d	26.15d	31.61d
Level of significant		**	**	**
SE (±)		0.29	0.69	0.98
CV (%)		35.53	27.43	20.20

The highest organic carbon content (3.38 t ha^{-1}) was found for Hybrid hira rice shoots which differed significantly from the total shoot carbon contents of the shoots of other varieties except that of BRRI dhan28 and BRRI dhan29. The lowest organic carbon content in shoot (2.10 t ha^{-1}) was found for Binadhan-5 which didn't differ significantly from that of Laphadhan (2.39 t ha^{-1}).

The highest total (root + shoot) organic carbon content (4.74 t ha^{-1}) was recorded for the hybrid hira which was statistically higher over all other rice varieties. The lowest total organic carbon content (2.92 t ha^{-1}) was recorded for the Binadhan-5 which was statistically at par with total carbon content of Laphadhan (2.94 t ha^{-1}), Pijamdhan (3.39 t ha^{-1}), Binadhan-7 (3.41 t ha^{-1}) and Hybrid tia (3.45 t ha^{-1}).

Nitrogen content (kg ha⁻¹) of root and shoot

The root N content varied from 3.97 kg ha^{-1} to 12.80 kg ha^{-1} (Table 3). The highest root N content (12.80 kg ha^{-1}) was found for Hybrid hira which was statistically superior to root N contents of rest seven varieties. Binadhan-7 (11.6 kg ha^{-1}) ranked second which was statistically superior to other six varieties. The lowest root N content (3.97 kg ha^{-1}) was observed for Laphadhan.

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

Group of variety	Name of the varieties	Phosphorus content (kg ha^{-1})		Total Phosphorus content (kg ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	3.19a	22.96a	26.15a
	Hybrid tia	1.48cd	15.79b	17.27b
BRRI	BRRI dhan28	0.65d	12.98d	13.63bcd
	BRRI dhan29	2.15bc	15.26bc	17.41b
BINA	Binadhan-5	1.67c	13.65cd	15.32bc
	Binadhan-7	3.13a	13.64cd	16.77bc
Local	Laphadhan	2.78ab	8.36f	11.14d
	Pijamdhan	1.90c	10.98e	12.88cd
Level of significant		*	**	**
SE (±)		0.37	0.59	1.66
CV (%)		40.27	29	42.30

The shoot N content varied from 14.42 kg ha^{-1} to 42.13 kg ha^{-1}. The shoots of Hybrid tia contained the highest N (42.13 kg ha^{-1}) which differed statistically from the shoot carbon contents of all other varieties except Binadhan-7 (41.98 kg ha^{-1}). The lowest shoot N content (14.42 kg ha^{-1}) was recorded for Binadhan-5 which was statistically lower than N contents of the shoots of other seven varieties. The statistically significant second highest value was 34.31 kg N ha^{-1} found for Hybrid hira which was statistically similar to that of BRRI dhan28 (32.95 kg ha^{-1}).

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

Group of variety	Name of the varieties	Potassium content (kg ha^{-1})		Total Potassium content (kg ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	19.24a	90.52a	109.76a
	Hybrid tia	6.62c	74.27c	80.89c
BRRI	BRRI dhan28	2.28e	74.19c	76.47cd
	BRRI dhan29	8.21b	85.64b	93.85b
BINA	Binadhan-5	8.14b	66.20d	74.34d
	Binadhan-7	7.94b	82.39b	90.33b
Local	Laphadhan	3.40d	60.38e	63.78e
	Pijamdhan	7.62b	49.77f	57.39f
Level of significant		**	**	**
SE (±)		0.33	1.30	1.63
CV (%)		61.63	17.96	45.59

The total N content of shoots plus roots of Binadhan-7 (53.74 kg ha^{-1}) was found the highest and differed significantly from that of rest seven varieties. The total N content (roots and shoots) of Binadhan-5 (22.77 kg ha^{-1}) was found statistically lower than that of the rest seven varieties. The total N content of shoot and root of Hybrid hira (47.11 kg ha^{-1}) and Hybrid tia (48.19 kg ha^{-1}) were found statistically identical.

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

The roots of Hybrid hira assimilated the higher amount of P (3.19 kg ha^{-1}) which did not differ statistically with the root P content of Binadhan-7 (3.13 kg ha^{-1}), Laphadhan (2.78 kg ha^{-1}) at 5% level of significance (Table 4). The lowest root P content was observed for the BRRI dhan28 (0.65 kg ha^{-1}) which did not differ significantly at 5% level from the root P content of Hybrid tia (1.48 kg ha^{-1}),

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

Group of variety	Name of the varieties	Sulphur content (kg ha^{-1})		Total Sulphur content (kg ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	21.25a	21.87d	43.12b
	Hybrid tia	9.84d	9.13f	18.97ef
BRRI	BRRI dhan28	6.02e	15.03e	21.05e
	BRRI dhan29	11.78c	27.16b	38.94c
BINA	Binadhan-5	14.08b	32.53a	46.61a
	Binadhan-7	13.15b	24.48c	37.63c
Local	Laphadhan	3.24f	13.23e	16.47f
	Pijamdhan	11.42c	13.71e	25.13d
Level of significant		**	**	**
SE (±)		0.45	0.62	1.07
CV (%)		45.77	39.51	36.70

On the other hand, the highest phosphorous content (22.96 kg ha^{-1}) in shoot was recorded for Hybrid hira which was statistically significantly different from the shoot P contents of other seven rice varieties. The lowest shoot phosphorous content (8.36 kg ha^{-1}) was observed for Laphadhan which was also statistically lower compared to shoot P contents of all other varieties.

The total phosphorous content of roots plus shoots (26.15 kg ha^{-1}) was found for Hybrid hira which was statistically higher from the total phosphorous contents of other seven varieties.

The lowest total phosphorous content (11.14 kg ha^{-1}) was observed for Laphadhan which was statistically similar to that of BRRI dhan28 (13.63 kg ha^{-1}) and Pijamdhan (12.88 kg ha^{-1}). The second highest total phosphorous content was found for BRRI dhan29 (17.41 kg ha^{-1}) which was statistically at par with such P contents of Hybrid tia (17.27 kg ha^{-1}), Binadhan-7 (16.77 kg ha^{-1}) and Binadhan-5 (15.32 kg ha^{-1}).

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

Group of variety	Name of the varieties	Sulphur content (kg ha^{-1})		Total Sulphur content (kg ha^{-1})
		Root	Shoot	
Hybrid	Hybrid hira	21.25a	21.87d	43.12b
	Hybrid tia	9.84d	9.13f	18.97ef
BRRI	BRRI dhan28	6.02e	15.03e	21.05e
	BRRI dhan29	11.78c	27.16b	38.94c
BINA	Binadhan-5	14.08b	32.53a	46.61a
	Binadhan-7	13.15b	24.48c	37.63c
Local	Laphadhan	3.24f	13.23e	16.47f
	Pijamdhan	11.42c	13.71e	25.13d
Level of significant		**	**	**
SE (±)		0.45	0.62	1.07
CV (%)		45.77	39.51	36.70

Potassium content (kg ha⁻¹) of root and shoot

The highest root K content (19.24 kg ha^{-1}) was found for hybrid hira which was statistically superior to root K contents of other seven varieties (Table 5). The second highest root potassium content (8.21 kg ha^{-1}) was observed for BRRI dhan 29 which did not differ statistically from K contents of Binadhan-5 (8.14 kg ha^{-1}), Binadhan-7 (7.94 kg ha^{-1}) and Pijamdhan (7.62 kg ha^{-1}). The lowest root potassium content (2.28 kg ha^{-1}) was observed for BRRI dhan 28.

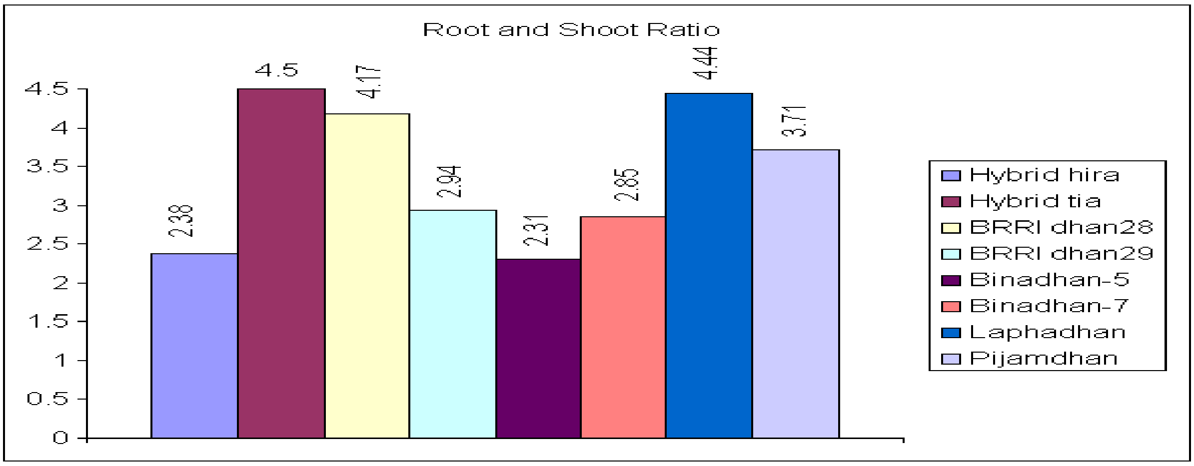

Fig. 1. Root and shoot ratio

The highest potassium content (90.52 kg ha^{-1}) in shoots was obtained for Hybrid hira which was statistically superior to the K contents in shoots of other seven varieties. The lowest shoot potassium content (49.77 kg ha^{-1}) was observed for Pijamdhan which was statistically inferior to that of other seven varieties.

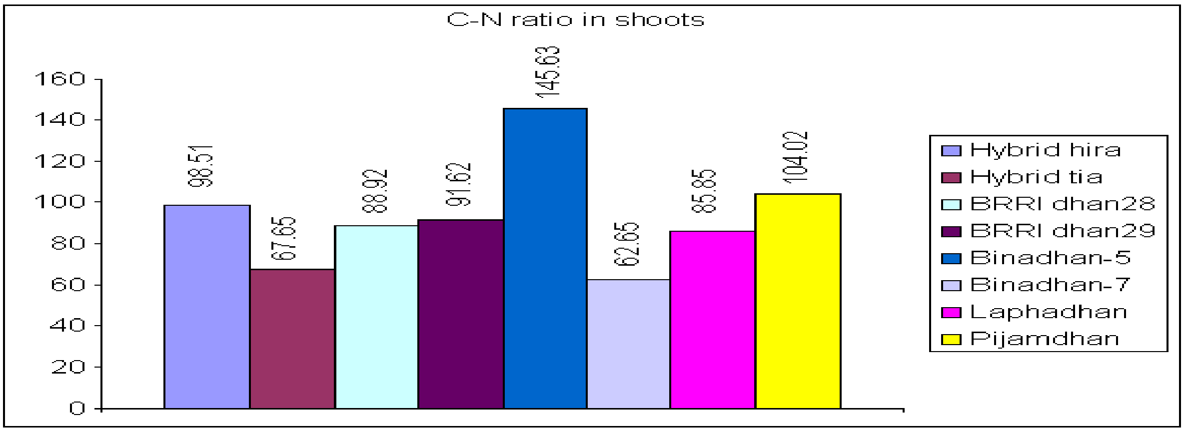

Fig. 2. C/N ratio in shoots

The highest total root plus shoot K content (109.76 kg ha^{-1}) was recorded for Hybrid hira which was statistically superior to total K contents of other seven varieties. The second highest root and shoot K content (93.85 kg ha^{-1}) was recorded for BRRI dhan29 which was statistically similar to K content of Binadhan-7 (90.33 kg ha^{-1}). The total potassium content of Hybrid tia was 80.89 kg ha^{-1} which was statistically similar to K content of BRRI dhan28 (76.47 kg ha^{-1}).

Sulphur content (kg ha⁻¹) of root and shoot

The highest root sulphur content (21.25 kg ha^{-1}) was shown by Hybrid hira which was statistically higher compared to S contents of other seven varieties (Table 6).

On the other hand, the lowest root sulphur content (3.24 kg ha^{-1}) was observed for Laphadhan which was statically lower than that of all others.

The highest sulphur content (32.53 kg ha^{-1}) in shoot was recorded for Binadhan-5 which was statistically higher over S contents of other seven varieties. The lowest shoot sulphur content (9.13 kg ha^{-1}) was observed for Hybrid hira which was statistically lower compared to S contents of rest seven varieties.

The highest total root plus soot sulphur content (46.61 kg ha^{-1}) was found for Binadhan-5 which was statistically higher over S contents of other seven varieties. The lowest total sulphur content (16.47 kg ha^{-1}) was observed for Laphadhan which was statistically similar S contents of Hybrid tia (18.97 kg ha^{-1}).

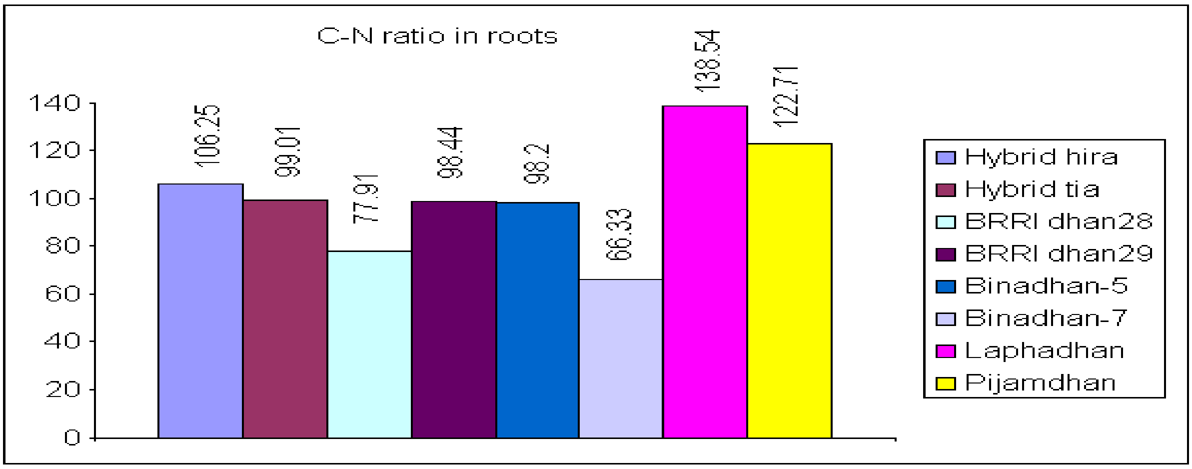

Fig. 3. C/N ratio in roots

Carbon-nitrogen ratio

The highest C-N ratio of 145.63 in shoot was found for Binadhan-5 which was significantly higher over other seven rice varieties. The lowest C-N ratio was 62.65 recorded for Binadhan-7 (Fig. 2).

The roots of Laphadhan had the highest C-N ratio of 138.54 which was statistically higher over the C-N ratio of the rest seven rice varieties. The lowest C-N ratio of 66.33 was found in the roots of Binadhan-7 (Fig. 3).

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 vegetative stage (72 DAT) 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.

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