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Effect of Integrated Nutrient Management and Plant Geometry on Growth and Quality of Rice (*Oryza sativa* L.) Varieties under SRI Technique

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A B S T R A C T

The present investigation was conducted with the objective to know the effect of integrated nutrient management and plant geometry on growth and yield attributes of rice varieties during *Kharif* season of 2015 and 2016. The study comprised six treatments of integrated nutrient management (F_0: Control, F_1: RDF (120:60:60) F_2: 50% RDF + 50% Vermicompost, F_3: 75% RDF + 25% N through Vermicompost, F_4: 50% RDF + 50% N through FYM F_5: 75% RDF + 25% N through FYM) with two varieties namely NDR-359 and Sarju 52 and two plant geometry (a) S_1: 20 cm × 20 cm. (b) S_2: 30 cm × 30 cm. the present investigation showed that the growth attributes were significantly influence due to different combination of organic and inorganic nutrients, varieties and plant geometry during both the years and in pooled analysis. The growth attributes *viz.*, plant height (cm), number of shoots (m^{-2}), dry matter accumulation (g m^{-2}) at 30, 60, 90 DAT and at harvest and leaf area index at 30, 60 and 90 DAT were recorded significantly higher with the application of integrated nutrient management treatment F_2 (50% RDF + 50% N through vermicompost). The variety V_1 (NDR-359) and plant geometry S_1 (20 cm × 20 cm) were recorded significantly higher growth attributes *viz.,* plant height (cm), number of shoots (m^{-2}), dry matter accumulation and leaf area index under SRI technique during both the year and in pooled analysis. The quality attributes like hulling % and protein content in grain were recorded in INM treatment F_2, variety V_1 and plant geometry S_1 during both the years and in pooled analysis.

Keywords

Rice varieties, Growth attributes, Quality, SRI.

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Introduction

Rice (*Oryza sativa* L.) is a member of poaceae family and is relished as staple food by majority of world's population. In India, rice occupied 45.16 million hectares area with a production of 103.72 million tonnes and average yield 2.7t ha^{-1} (Anonymous, 2015). Rice is grown in 114 countries across the world on an area about 150 million hectares with annual production of over 525 million tonnes, constituting nearly 11 per cent of the world's cultivated land. The system of Rice Intensification (SRI) was developed by a Jesuit agriculturist Fr. Henri De Laulanie (1993) and Madagascar colleagues working with him in 1980 and the 1990, and they studied ways to increase the low yields of Madagascar farmers. From Madagascar's poor soils which yielded usually an average of 2 tonnes per hectare. SRI system coaxed yield of 6, 8 and even 10 tonnes per hectare, while reducing the farmers' cost for water, seeds and external inputs. In 1990, Fr. De Laulanie and his colleagues set up an NGO called Association Tefy Saina ('to improve the mind') to develop SRI further and to promote it among Madagascar farmers.

The System of Rice Intensification (SRI) increase opportunity to improve food security through increased rice productivity by changing the management of plants, soil, water and nutrients while reducing external inputs like seed, water, fertilizers and herbicides.

The SRI system has its own methodologies that include transplanting of very young seedling (8-15 days old), transplanting single seedling per hill at square pattern of 25 cm x 25 cm, 30 cm x 30 cm (wider spacing), use of mechanical weeder to aerate the soil/plant system, alternate wetting and drying the soil (soil not flooded during the vegetation period) and use of organic manure as nutrient source. Long duration varieties perform better with wider spacing than short duration varieties (Baloch *et al.,* 2002). Stoop (2005) suggested that long-duration varieties perform better under SRI management. Proponents of SRI recommend the use of organic fertilization (compost) instead of chemical fertilizer.

Materials and Methods

The field experiment was conducted during *Kharif* 2015 and 2016 at Agronomy Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.). The experimental site located at Kumarganj is situated 42 km away from Faizabad city on Faizabad- Raibarely road. Geographically the experimental site is situated at 26.47^0 North latitude and 81.12^0 East longitude with is an elevation of about 113 m. from mean sea level in the Indo Gangatic Plain Zone of eastern Uttar Pradesh.

The climate in this region is humid and characterized with high rainfall (300 cm $year^{-1}$). The soil is sandy to sandy loam with a pH of 5.05 and 0.72% organic C. Soil low in available N (127.92 kg ha^{-1}), medium in available P (21.59 kg ha^{-1}) and low in available K (122.46 kg ha^{-1}).

The treatment was carried out with 24 treatment combination formed with six nutrient management levels, two varieties and two levels of plant geometry, in rice which were allocated in split plot design with three replications.

The six irrigation levels (a) N_0: Control (b) N_1: RDF (120:60:60) (c) N_2: 50% RDF + 50% Vermicompost (d) N_3: 75% RDF + 25% Vermicompost (e) N_4: 50% RDF + 50% FYM (f) N_5: 75% RDF + 25% FYM with two varieties namely NDR-359 and Sarju 52 and two plant geometry (a) S_1: 20 cm X 20 cm. (b) S_2: 30 cm X 30 cm

The crop was fertilised with a uniform dose of 60 kg P_2O_5/ha through single super phosphate, 40 kg K_2O/ha through muriate of potash and half dose of the Nitrogen management as per treatments with organic and inorganic.

The number of shoots were counted at 30, 60, 90 DAS and at harvest by placing quadrate at three places in each plot and the plants which come within the quadrate were averaged out to express shoots per square meter Number of effective tillers (ear heads) were counted before harvesting from marked area of one square meter, Total number of spikelets from five selected spikes was counted and average values were recorded. From the individual plot the crop of net plot area was harvested. After air d harvesting and seed were cleaned. The final seed weight was recorded in kg per plot and converted in to t/ha.

Results and Discussion

Effect of integrated nutrient management treatments growth attributes

Nutrient is the fundamental basis of life. Growth of plant is controlled by rates of cell division, their enlargement and by the supply of organic and inorganic compounds required for the synthesis of new protoplasm and cell wall. Cell enlargement is particularly dependent on least minimum degree of cell turgor. Stem and leaf elongation is quickly checked by nutrient. Thus decreasing nutrient content is accompanied by loss of turgor and wilting, cessation of cell enlargement, closure of stomata, reduction in photosynthesis and interference with many basic metabolic processes.

Integrated Nutrient Management did not change initial plant population significantly because there was uniform nutrient at the time of planting which lead proper standing of crop. This was mainly due to the effect of initial plant population was counted as 5 days of transplanting and nutrient treatments were applied up to this period (Table 1). This might be due to no application of differential irrigation up to this stage (Rath *et al.,* 2010) and (shekara *et al.,* 2011).

Different integrated nutrient management showed significant effect on growth characters *viz.,* plant height and number of shoots m^{-2} as well as leaf area index at 30, 60, 90 DAT and at harvest stage (Table-2). The plant height show variation significantly due to different nutrient management at growth stage (30 DAT) because variable nutrient was received this stage under different integrated nutrient management, the maximum plant height was recorded with the application of F_2 (50 % RDF + 50 % N through vermicompost) which, was significantly superior to the F_0 (control), F_1-RDF (120:60:60), F_5(75% RDF + 25% N through FYM) and F_3 (75% RDF + 25% N through vermicompost) at 30, 60, 90 DAT and at harvest. It was statistically at par with treatment F_4 (50 % RDF + 50 % N through FYM). However, the minimum plant height was observed in F_0 (control) at 30, 60, 90 DAT and at harvest. Significant reduction in plant height due to decrease in nutrient availability was also reported by Das *et al.,* (2002), Dutt & Chauhan (2010), Gautam *et al.,* (2012) and Kumar *et al.,*(2012).

The maximum effect of nutrients level on number of shoots was recorded with the application of F_2 (50 % RDF + 50 % N through vermicompost) which, was significantly higher than F_0 (control), F_1-RDF (120:60:60), F_5 (75% RDF + 25% N through FYM) and F_3 (75% RDF + 25% N through vermicompost) (Table-3). It was statistically at par with treatment F_4 (50 % RDF + 50 % N through FYM). However, the minimum number of shoots was observed in F_0 (control) at 30, 60, 90 DAT and at harvest.

Similar result was also reported by Rathi and Narine (1990), Das *et al.,* (2002), Mirza *et al.,* (2005), Dutt and Chauhan (2010) and Kumar *et al.,* (2012). In general number of shoots was lowest for initial crop growth period which increased with the increasing crop age. The number of shoots was received maximum during 60-90 DAT and more after it decline gradually (Dutt and Chauhan, 2010).

The dry matter accumulation recorded maximum with the application of F_2 (50 % RDF + 50 % N through vermicompost) which, was significantly higher dry matter accumulation than rest of other INM treatments except treatment F_4 (50 % RDF + 50 % N through FYM). It was statistically at par with treatment F_4 (50 % RDF + 50 % N through FYM). However, the minimum dry matter accumulation was observed in F_0 - (control) at 30, 60, 90 DAT and at harvest, respectively Vanaja and Raju (2002), Shekhara *et al.,* (2011).

Table.1 Effect of integrated nutrient management, varieties and plant geometry on initial plant population (m^{-2}) of rice under SRI technique

Treatment	Initial plant population (m^{-2})		
	2015	**2016**	**Pooled**
Nutrients management			
F_0: Control	18.06	18.06	18.06
F_1: RDF (120:60:60)	18.06	18.06	18.06
F_2: 50% RDF + 50% N-Vermicompost	18.06	18.06	18.06
F_3: 75% RDF + 25% N-Vermicompost	18.06	18.06	18.06
F_4: 50% RDF + 50% N-FYM	18.06	18.06	18.06
F_5: 75% RDF + 25%N- FYM	18.06	18.06	18.06
SEm±	**0.34**	**0.34**	**0.24**
CD at 5%	**NS**	**NS**	**NS**
Varieties			
V_1:NDR-359	18.06	18.06	18.06
V_2: Sarju 52	18.06	18.06	18.06
SEm±	**0.20**	**0.20**	**0.14**
CD at 5%	**NS**	**NS**	**NS**
Plant geometry			
S_1: 20 cm × 20 cm	25.00	25.00	25.00
S_2: 30 cm × 30 cm	11.11	11.11	11.11
SEm±	**0.20**	**0.20**	**0.14**
CD at 5%	**0.57**	**0.57**	**0.40**

Table.2 Effect of integrated nutrient management, varieties and plant geometry on plant height (cm) of rice under SRI technique

Treatment	Plant height (cm) at 30 DAT			Plant height (cm) at 60 DAT			Plant height (cm) at 90 DAT			Plant height (cm) at harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Nutrients management												
F_0	36.19	37.15	36.67	60.06	61.75	60.91	74.07	75.31	74.69	76.62	77.92	77.27
F_1	47.47	48.73	48.10	78.78	81.00	79.89	97.16	98.78	97.97	100.50	102.21	101.35
F_2	51.70	53.08	52.39	85.80	88.22	87.01	105.82	107.58	106.70	109.45	111.32	110.39
F_3	48.88	50.18	49.53	81.12	83.41	82.26	100.05	101.71	100.88	103.48	105.25	104.36
F_4	49.82	51.15	50.48	82.68	85.01	83.85	101.97	103.67	102.82	105.47	107.27	106.37
F_5	47.94	49.22	48.58	79.56	81.80	80.68	98.12	99.76	98.94	101.49	103.22	102.36
SEm ±	**0.90**	**0.92**	**0.64**	**1.48**	**1.53**	**1.06**	**1.83**	**1.89**	**1.32**	**1.89**	**1.96**	**1.36**
CD at 5%	**2.57**	**2.61**	**1.92**	**4.22**	**4.34**	**2.99**	**5.21**	**5.38**	**3.91**	**5.39**	**5.57**	**4.05**
Varieties												
V_1	47.94	49.22	48.58	80.89	83.17	82.03	99.76	101.42	100.59	103.18	104.94	104.06
V_2	46.06	47.29	46.67	75.11	77.23	76.17	92.64	94.18	93.41	95.82	97.46	96.64
SEm±	**0.52**	**0.53**	**0.37**	**0.86**	**0.88**	**0.61**	**1.06**	**1.09**	**0.76**	**1.09**	**1.13**	**0.79**
CD at 5%	**1.48**	**1.51**	**1.04**	**2.44**	**2.51**	**3.17**	**3.01**	**3.11**	**2.13**	**3.11**	**3.22**	**2.21**
Plant geometry												
S_1	48.41	49.70	49.05	80.34	82.61	81.47	99.09	100.73	99.91	102.49	104.24	103.36
S_2	45.59	46.80	46.20	75.66	77.79	76.73	93.31	94.87	94.09	96.52	98.16	97.34
SEm±	**0.52**	**0.53**	**0.37**	**0.86**	**0.88**	**0.61**	**1.06**	**1.09**	**0.76**	**1.09**	**1.13**	**0.79**
CD at 5%	**1.48**	**1.51**	**1.04**	**2.44**	**2.51**	**1.73**	**3.01**	**3.11**	**2.13**	**3.11**	**3.22**	**2.21**

Table.3 Effect of integrated nutrient management, varieties and plant geometry on number of shoots (m^{-2}) of rice under SRI technique

Treatment	Number of shoots (m^{-2}) at 30 DAT			Number of shoots (m^{-2}) at 60 DAT			Number of shoots (m^{-2}) at 90 DAT			Number of shoots (m^{-2}) at harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Nutrients management												
F_0	126.92	130.22	128.57	270.06	279.70	274.88	270.90	281.85	276.38	245.88	250.80	248.34
F_1	187.04	191.85	189.44	397.88	412.09	404.98	444.80	462.78	453.79	403.72	411.79	407.75
F_2	194.01	199.00	196.50	412.70	427.44	420.07	558.40	580.97	569.69	506.83	516.96	511.89
F_3	190.24	195.13	192.69	404.69	419.14	411.91	504.00	524.37	514.19	457.45	466.59	462.02
F_4	192.13	197.06	194.60	408.69	423.29	415.99	531.20	552.67	541.94	482.14	491.78	486.96
F_5	189.68	194.55	192.12	403.48	417.89	410.69	481.95	501.43	491.69	437.43	446.18	441.81
SEm ±	**3.42**	**3.49**	**2.44**	**7.28**	**7.51**	**5.23**	**9.24**	**9.62**	**6.67**	**8.39**	**8.56**	**5.99**
CD at 5%	**9.73**	**9.95**	**6.87**	**20.74**	**21.37**	**14.69**	**26.31**	**27.37**	**18.73**	**23.88**	**24.35**	**16.83**
Varieties												
V_1	183.43	191.77	187.60	397.71	411.92	404.81	473.60	492.74	483.17	429.86	438.45	434.15
V_2	176.57	177.50	177.04	368.12	381.27	374.70	456.82	475.28	466.05	414.62	422.91	418.77
SEm±	**1.97**	**2.02**	**1.41**	**4.21**	**4.33**	**3.02**	**5.34**	**5.55**	**3.85**	**4.84**	**4.94**	**3.46**
CD at 5%	**5.62**	**5.74**	**3.96**	**11.97**	**12.34**	**8.48**	**15.19**	**15.80**	**10.81**	**13.79**	**14.06**	**9.71**
Plant geometry												
S_1	187.02	191.84	189.43	397.85	412.06	404.96	506.83	527.32	517.08	460.02	469.22	464.62
S_2	172.98	177.43	175.21	367.98	381.12	374.55	423.58	440.70	432.14	384.46	392.14	388.30
SEm±	**1.97**	**2.02**	**1.41**	**4.21**	**4.33**	**3.02**	**5.34**	**5.55**	**3.85**	**4.84**	**4.94**	**3.46**
CD at 5%	**5.62**	**5.74**	**3.96**	**11.97**	**12.34**	**8.48**	**15.19**	**15.80**	**10.81**	**13.79**	**14.06**	**9.71**

Table.4 Effect of integrated nutrient management, varieties and plant geometry on dry matter accumulation (g m^{-2}) of rice under SRI technique

Treatment	Dry matter accumulation at 30 DAT			Dry matter accumulation at 60DAT			Dry matter accumulation at 90DAT			Dry matter accumulation at harvest		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Nutrients management												
F_0	98.24	108.24	103.24	274.54	320.31	297.42	439.07	447.54	443.30	627.90	632.30	630.10
F_1	137.30	146.96	142.13	545.80	574.33	560.07	720.92	734.82	727.87	1030.96	1038.19	1034.58
F_2	152.84	163.59	158.22	585.28	615.89	600.59	905.04	922.49	913.77	1294.27	1303.34	1298.80
F_3	146.60	158.57	152.59	572.17	602.09	587.13	816.87	832.62	924.25	1168.18	1176.37	1172.27
F_4	147.30	159.35	153.32	575.18	605.29	590.24	860.96	877.56	859.26	1231.22	1239.85	1235.54
F_5	137.25	148.73	142.99	550.04	578.75	564.40	781.13	796.19	788.66	1117.06	1124.89	1120.98
SEm ±	**2.60**	**2.79**	**1.91**	**9.82**	**10.42**	**7.16**	**14.98**	**15.27**	**10.69**	**21.42**	**21.57**	**15.20**
CD at 5%	**7.39**	**7.95**	**5.66**	**27.97**	**29.67**	**20.11**	**42.64**	**43.86**	**30.06**	**60.98**	**61.40**	**42.69**
Varieties												
V_1	144.66	156.07	150.37	535.30	569.53	552.41	767.60	782.40	775.00	1097.72	1105.41	1101.56
V_2	128.35	138.91	133.63	499.03	529.37	514.20	740.40	754.67	747.54	1058.81	1066.24	1062.53
SEm±	**1.50**	**1.61**	**1.10**	**5.67**	**6.02**	**4.13**	**8.65**	**8.81**	**6.17**	**12.37**	**12.45**	**8.78**
CD at 5%	**4.27**	**4.59**	**3.09**	**16.15**	**17.13**	**11.61**	**24.62**	**25.09**	**17.34**	**35.20**	**35.45**	**24.65**
Plant geometry												
S_1	143.54	154.42	148.98	535.60	568.98	552.29	821.47	737.31	729.39	1174.75	1182.98	1178.86
S_2	129.47	140.55	135.01	498.74	529.92	514.33	686.53	699.77	693.15	981.78	988.67	985.23
SEm±	**1.50**	**1.61**	**1.10**	**5.67**	**6.02**	**4.13**	**8.65**	**8.81**	**6.17**	**12.37**	**12.45**	**8.78**
CD at 5%	**4.27**	**4.59**	**3.09**	**16.15**	**17.13**	**11.61**	**24.62**	**25.09**	**17.34**	**35.20**	**35.45**	**24.65**

Table.5 Effect of integrated nutrient management, varieties and plant geometry on leaf area index of rice under SRI technique

Treatment	Leaf area index at 30 DAT			Leaf area index at 60 DAT			Leaf area index at 90 DAT		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Nutrients management									
F_0	2.50	2.57	2.53	3.45	3.49	3.47	3.75	3.81	3.78
F_1	2.78	2.86	2.82	3.79	3.83	3.81	4.12	4.19	4.16
F_2	2.88	2.97	2.93	3.93	3.98	3.96	4.27	4.35	4.31
F_3	2.83	2.91	2.87	3.86	3.90	3.88	4.19	4.26	4.23
F_4	2.86	2.94	2.90	3.90	3.94	3.92	4.23	4.30	4.27
F_5	2.82	2.90	2.86	3.85	3.89	3.87	4.18	4.25	4.21
SEm ±	**0.05**	**0.05**	**0.04**	**0.07**	**0.07**	**0.05**	**0.08**	**0.08**	**0.06**
CD at 5%	**0.15**	**0.16**	**0.11**	**0.21**	**0.21**	**0.15**	**0.23**	**0.23**	**0.16**
Varieties									
V_1	2.90	2.98	2.94	3.96	4.00	3.98	4.30	4.38	4.34
V_2	2.66	2.73	2.70	3.63	3.67	3.65	3.95	4.01	3.98
SEm±	**0.03**	**0.03**	**0.02**	**0.04**	**0.04**	**0.03**	**0.05**	**0.05**	**0.03**
CD at 5%	**0.09**	**0.09**	**0.06**	**0.12**	**0.12**	**0.08**	**0.13**	**0.13**	**0.09**
Plant geometry									
S_1	2.86	2.95	2.91	3.91	3.95	3.93	4.25	4.32	4.28
S_2	2.69	2.77	2.73	3.68	3.72	3.70	4.00	4.07	4.03
SEm±	**0.03**	**0.03**	**0.02**	**0.04**	**0.04**	**0.03**	**0.05**	**0.05**	**0.03**
CD at 5%	**0.09**	**0.09**	**0.06**	**0.12**	**0.12**	**0.08**	**0.13**	**0.13**	**0.09**

Table.6 Effect of integrated nutrient management, varieties and plant geometry on Hulling, protein content in grain and N uptake of rice under SRI technique

Treatment	Hulling (%)			Protein content in grain (%)			Total N uptake (kg ha^{-1})		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Nutrients management									
F_0	64.76	66.06	65.41	7.02	7.09	7.06	59.61	63.16	61.38
F_1	65.43	66.08	65.75	7.15	7.22	7.18	78.78	83.58	81.18
F_2	68.21	68.89	68.55	7.84	7.91	7.88	93.53	99.05	96.29
F_3	67.02	67.55	67.29	7.40	7.47	7.44	84.62	89.77	87.19
F_4	67.70	68.38	68.04	7.68	7.76	7.72	89.02	94.38	91.70
F_5	66.11	66.78	66.44	7.27	7.35	7.31	80.91	85.85	83.38
SEm ±	**1.30**	**1.31**	**0.92**	**0.14**	**0.15**	**0.10**	**1.55**	**1.65**	**1.13**
CD at 5%	**3.69**	**3.74**	**2.59**	**0.41**	**0.41**	**0.29**	**4.42**	**4.72**	**3.18**
Varieties									
V_1	66.86	67.74	67.30	7.40	7.48	7.44	84.23	89.29	86.76
V_2	66.22	66.84	66.53	7.39	7.46	7.42	77.92	82.64	80.28
SEm±	**0.75**	**0.76**	**0.53**	**0.08**	**0.08**	**0.06**	**0.90**	**0.95**	**0.65**
CD at 5%	**2.13**	**2.16**	**1.50**	**NS**	**NS**	**NS**	**2.55**	**2.71**	**1.84**
Plant geometry									
S_1	66.75	67.37	67.06	7.36	7.43	7.39	83.04	88.04	85.54
S_2	66.33	67.21	66.77	7.43	7.50	7.47	79.12	83.89	81.51
SEm±	**0.75**	**0.76**	**0.53**	**0.08**	**0.08**	**0.06**	**0.90**	**0.95**	**0.65**
CD at 5%	**2.13**	**2.16**	**1.50**	**NS**	**NS**	**NS**	**2.55**	**2.71**	**1.84**

The leaf area index was increased very slowly over a fairly long period (60 DAS) and ushered in a period of rapid expansion possibly because of increased light absorption and high photosynthetic activities. As leaf area increases, light absorption and rate of dry matter production increase till the foliage become sufficiently dense to cause mutual shading resulting reduced photosynthetic activity of lower leaves.

Leaf area index was also significantly influenced by nutrient management at 30, 60 and 90 DAT. Significantly higher leaf area index was observed with the application of F_2 (50 % RDF + 50 % N through vermicompost) which was significantly higher than control (F_0). It was statistically at par with F_1-RDF (120:60:60), F_3 (75 % RDF + 25 % N- through Vermicompost), F_4 (50% RDF+50 % N- through FYM) and F_5 (75% RDF+25 % N- through FYM).

Increase in leaf area index with increasing nutrient availability might be due to the fact that nutrient supply contributed towards to more number of green leaves, which attributed to high leaf area and leaf area index. The lowest leaf area index was recorded under in F_0 (control). The results were in proximity to those of Sharma and Mitra (1992) and (Shankar and Laware, 2011).

Effect of varieties on growth attributes

Plant growth and yield are governed by the combined effects of inherited genetic potential and environment in which plants are grown. There is vital role of selection of cultivar in paddy crop because of the fact that variation in the duration, photo-sensitiveness, thermo-sensitiveness and vegetative lag period of the variety. A variety of short duration completes their life cycle with in short period with less effect of photoperiod and low temperature. Longer duration varieties and photo and thermo insensitive varieties may perform better under favorable conditions.

The significant difference was not found in the initial plant population among the varieties. While significant differences in plant height, number of shoot m^{-2}, LAI and dry matter accumulation were recorded with variety NDR-359 at all the growth stage of crops. Similarly another growth characteristics and yield attributing characters showed the significant differences among the varieties. The variation in growth development and yield of varieties might be due to their genetic characteristics. Similar finding in respect to varieties were also reported by Dey *et al.,* (2006), Islam *et al.,* (2008), Limochi *et al.,* (2012) and Tyeb *et al.,* (2013).

Harvest index is the function of grain and straw yield which was significantly equal in both the varieties.

Among the cultivars of wheat included in experiment, NDR-359 has been found more promising in comparison to Sarju-52 to provide higher values of nutrient uptake as well as quality (protein content) during both of years.

The plant height recorded at all the stages of observations of crop was significantly higher in rice cultivar NDR-359 than the Sarjy-52 cultivars. The taller plant in cultivar NDR-359 might be due to better utilization of available growth resources like light and temperature which may result in more nitrogen absorption for the synthesis of protoplasm responsible for rapid cell division consequently increasing the plant in shape and size or may be due to vigour of the cultivar. Similar findings have also been reported by Dey *et al.,* (2006) Singh and Singh (2008) and Awasthe *et al.,* (2011).

The higher number of total tillers m^{-2} were recorded in cultivar NDR-359 (Table 4) might be due to ability of effective utilization of plant growth resources *viz.* photoperiod, dry matter production and increase in tillers with advancement of life cycle. The findings have also been supported by Singh and Singh (2008) and Dey *et al.,* (2006). The dry matter accumulation m^{-1} running row recorded at all the stages of observations of crop was significantly higher in cultivar NDR-359 than sarju-52 (Table 4). The higher dry matter accumulation m^{-1} running row in cultivar NDR-359 might be due significantly higher dry matter production m^{-1} running row at all the stages of observations.

The rice cultivar NDR-359 recorded significantly higher LAI at all the stages of observations than the rest of the Sarju-52 cultivar (Table 5). The higher LAI recorded in cultivar NDR-359 might be due to more number of leaves m^{-2}. The findings have also been supported by Singh and Singh (2008). At 90 DAT leaf area index of NDR-359 was not increased as high as other cultivars as it was a short duration crop and number of leaves m^{-2} were decreased at 90 DAS but leaf size increased. Thus leaf area index slightly increased reported by Dey *et al.,* (2006).

Quality traits

Hulling (%)

The hulling (%) was not influenced due to INM treatments, varieties and plant geometry. This result similarly found by Subhash *et al.,* (2005).

Protein content

The protein content in grain significantly influenced with application of various organic manures and fertilizers. The maximum protein content in grain was found with the application F_2 (50 % RDF + 50 % N through vermicompost) which was significantly higher over the F_0, $F_{1,}$ F_3 and F_5 INM treatments but at par with the F_4 INM treatment The lowest protein content was recorded in the treatment received only F_0 (Table-6). This was due to high nitrogen content and uptake by grains receiving sufficient and balanced nutrition. This might be attributed to better root development and higher nitrogen utilization by crop under adequate supply of N, P, K which enhanced the protein synthesis and ultimately increased protein content in grains. Dixit and Gupta (2000) reported that application of FYM @ 10 t ha^{-1} combined with BGA inoculation increased the protein and amylase content in rice. Varieties did not have significant effect on protein content and the plant geometry also S_1 (20 cm × 20 cm) and S_2 (30cm×30cm) did not have significant effect on protein content (Singh and Verma, 2006; Dewedi *et al.,* 2006).

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