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Changing pattern of plant height in rice cultivars with increased fertilizer

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ABSTRACT

One hundred rice cultivars with plant height range from 70 cm -150 cm was used to study the changing pattern of plant height with fertilizer application. A field experiment was carried out during 2011-2012 Maha season and 2012 Yala season at Faculty of Agriculture, University of Ruhuna, Sri Lanka. Germinated seeds were planted in rows with 15 cm X 20 cm spacing. Four plots were arranged and plots were separated from bunds to prevent mixing of fertilizer. Four fertilizer levels were provided to separated plots as no fertilizer, half of the recommended dose (x ½ RD), recommended dose (RD: Urea 50 kg ha^{-1}, TSP 62.5 kg ha^{-1}, MOP 50 kg ha^{-1}) and doubled the recommended dose (x 2 RD). Experiment was conducted with four replications according to the randomized complete block design and each replicate consisted of three lines. Twenty plants were included in to each line. Data were collected on plant height (cm) at maturity stage. Rice cultivars were grouped according to plant height at no fertilizer level: 70-79 cm, 80-89 cm, 90-99 cm, 100- 119 cm —139-149 cm, >150 cm etc. Changing pattern of plat height in different plant-height groups at different fertilizer levels was plotted. It was found that at shorter plant height groups (70-119 cm), plants increased the height with increased fertilizer while in 120-129 cm plant-height group, changing pattern of plant height was nearly in normal distribution. However the changing pattern of plant height in all the other plant height groups (> 130 cm) was sigmoid. It can be concluded that the elongation pattern of leaves or culms of rice plants with increased fertilizer depends on the initial plant height of rice cultivars at no fertilizer level.

***Keywords*: Plant height, MOP, TSP, Urea**

Some morphological traits associated with new plant architecture of rice have been found to have close relationship with yielding ability of rice variety (Yang *et al.,* 2007; Yang and Hwa, 2008). Plant height is a major contributor to the yield (Yadav *et al*., 2011) but greater plant height susceptible to lodging reduces yield, quality of production, and mechanical harvesting efficiency (Weber and Fehr, 1966). It was estimated that lodging caused a loss of 26 kg ha^{-1} in rice production in southern India (Duwayri *et al*., 2000). Roberts *et al.* (2013) have reported that the semi-dwarf cultivars produce higher yields than that of in tall cultivars. However the yield potential of rice cultivars is controlled by both genetic factors and environmental factors (Selvaraj *et al*., 2011). Plant height revealed significant positive correlations with yield (Ruben and Katuli, 1989; Kumar, 1992) but Hairmansis *et al*. (2010) noted that plant height had negative effect on grain yield. According to Khan *et al*. (2009) plant height had the highest direct effect on number of grains per panicle. Fertilizer increased most of the agro-morphological characteristics in rice. Fertilizer consumption depends on rice variety; soil condition and farmer practices (Hach and Nam, 2006). Efficiency of fertilizer on various rice cultivars have been studied previously and the results revealed that there is a potential to increase grain yield by application of fertilizer (Awan *et al*., 2011; Saleem *et al*., 2011; Bhuyan *et al.,* 2012). Saito *et al*., (2005) used three traditional and three improved cultivars to understand the effect of four fertilizer treatments: no added fertilizer, Nitrogen only (N; 90 kg N ha^{-1}), phosphate only (P; 50 kg P ha^{-1}), and N and P (NP) at three locations. The two improved cultivars, reported higher total dry matter and harvest index, lower plant height and more panicles than traditional cultivars. The present study was carried out to understand the effect of different levels of fertilizer on plant height in rice.

MATERIALS AND METHODS

One hundred rice cultivars including ninety four traditional and six improved rice accessions given in table 1, were collected from Plant Genetic Resources Center (PGRC, 1999). Seeds of these cultivars were geminated and planted in nursery beds. Ten days old seedlings were transplanted in the experimental field at the Faculty of Agriculture, Mapalana, Kamburupitiya, Sri Lanka.

To understand the effect of fertilizer on plant height, four different fertilizer levels were applied in to the field which was separated by bunds. Fertilizer levels were: no fertilizer, half of the recommended dose (x ½ RD), recommended dose (RD) and twice the recommended dose (x 2RD). The recommended fertilizer dose was basal dressing (Urea 50 kg ha^{-1}, TSP 62.5 kg ha^{-1}, MOP 50 kg ha^{-1}) before planting and top dressings (Urea 37.5 Kg ha^{-1}) two times at 2 weeks after planting and at 8 weeks after planting.

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Table 1: Rice accessions used for the experiment (PGRC,1999)

Sl. no	Accession no	Name	Sl. no	Accession no	Name
1	3673	*Kaluhandiran*	51	3645	*Muthumanikam*
2	3674	*Kirikara*	52	3646	*Induru Karayal*
3	3675	*Kotathavalu I*	53	3647	*Kalu gires*
4	3676	*Dena wee*	54	3650	*Madabaru*
5	3677	*Herath Banda*	55	3651	*Balakara*
6	3678	*Hondarawala*	56	3652	*Buruma Thavalu*
7	3679	*Kottakaram*	57	3517	*Seeraga Samba Batticaloa*
8	3681	*Dandumara*	58	3518	*H 10(Improved)*
9	3686	*Karayal I*	59	3519	*Manchel Perunel*
10	3687	*Dewaredderi*	60	3562	*Thunmar Hamara*
11	3469	*Sudu wee*	61	3567	*Dingiri Menika*
12	3477	*Sudu Goda wee*	62	3570	*Madael*
13	3479	*Kiri Naran*	63	3571	*Miti Riyan*
14	3480	*Karayal II*	64	3572	*Suduru Samba II*
15	3482	*Akuramboda*	65	3589	*Gangala*
16	3486	*Puwakmalata Samba*	66	3588	*Heenpodi wee*
17	3487	*Palasithari 601*	67	3497	*Sinnanayan 398*
18	3489	*Murungakayan 3*	68	3498	*Geeraga Samba*
19	3490	*Murungakayan 101*	69	3504	*Dik wee 328*
20	3496	*Bala Ma wee I*	70	3506	*MI 329(Improved)*
21	3654	*Pokuru Samba*	71	3507	*Suwanda Samba*
22	3655	*Rata wee*	72	3508	*Madael Galle*
23	3660	*Suduru*	73	3510	*Sudu wee Ratnapura*
24	3658	*Ingrisi wee*	74	3511	*Maha Murunga Badulla*
25	3659	*Kotathavalu II*	75	3514	*Madael Kalutara*
26	3653	*Kalu Karayal*	76	3516	*Seevalee Ratnapura*
27	3668	*Ranruwan*	77	3383	*EAT Samba*
28	3669	*Rajes*	78	3389	*Sirappu Paleusithri*
29	3670	*Madoluwa*	79	3394	*Muthu Samba*
30	3671	*Suduru Samba I*	80	3395	*Podi sudu wee*
31	3688	*Handiran*	81	3401	*Wanni Heenati*
32	3691	*Gunaratna*	82	3409	*BG 35-2(Improved)*
33	3661	*Polayal I*	83	3410	*BG 35-7(Improved)*
34	3664	*Tissa wee*	84	3415	*BG 34-8(Improved)*
35	3665	*Sudu Karayal*	85	3416	*A 6-10-37(Improved)*
36	3666	*Podisayam*	86	3417	*Periamorungan*
37	3423	*Giress*	87	3591	*Mudukiriel*
38	3427	*Naudu wee*	88	3594	*Suduru Samba III*
39	3434	*Kokuvellai*	89	3595	*Kaharamana II*
40	3463	*Karayal III*	90	3598	*Bala Ma wee II*
41	3438	*Murunga wee*	91	3606	*Chinnapodiyan*
42	3435	*Matara wee*	92	3607	*Kiri Murunga wee*
43	3440	*Kaharamana I*	93	3610	*Heendikki*
44	3447	*Karabewa*	94	3612	*Jamis wee I*
45	3451	*Halabewa*	95	3613	*Lumbini II*
46	3445	*Yakada wee I*	96	3614	*Sinnanayam*
47	3638	*Lumbini I*	97	3615	*Yakada wee II*
48	3639	*Polayal II*	98	3616	*Jamis wee II*
49	3641	*Heendik wee*	99	3550	*Bathkiri el*
50	3642	*Kahata Samba*	100	3713	*Kalukanda*

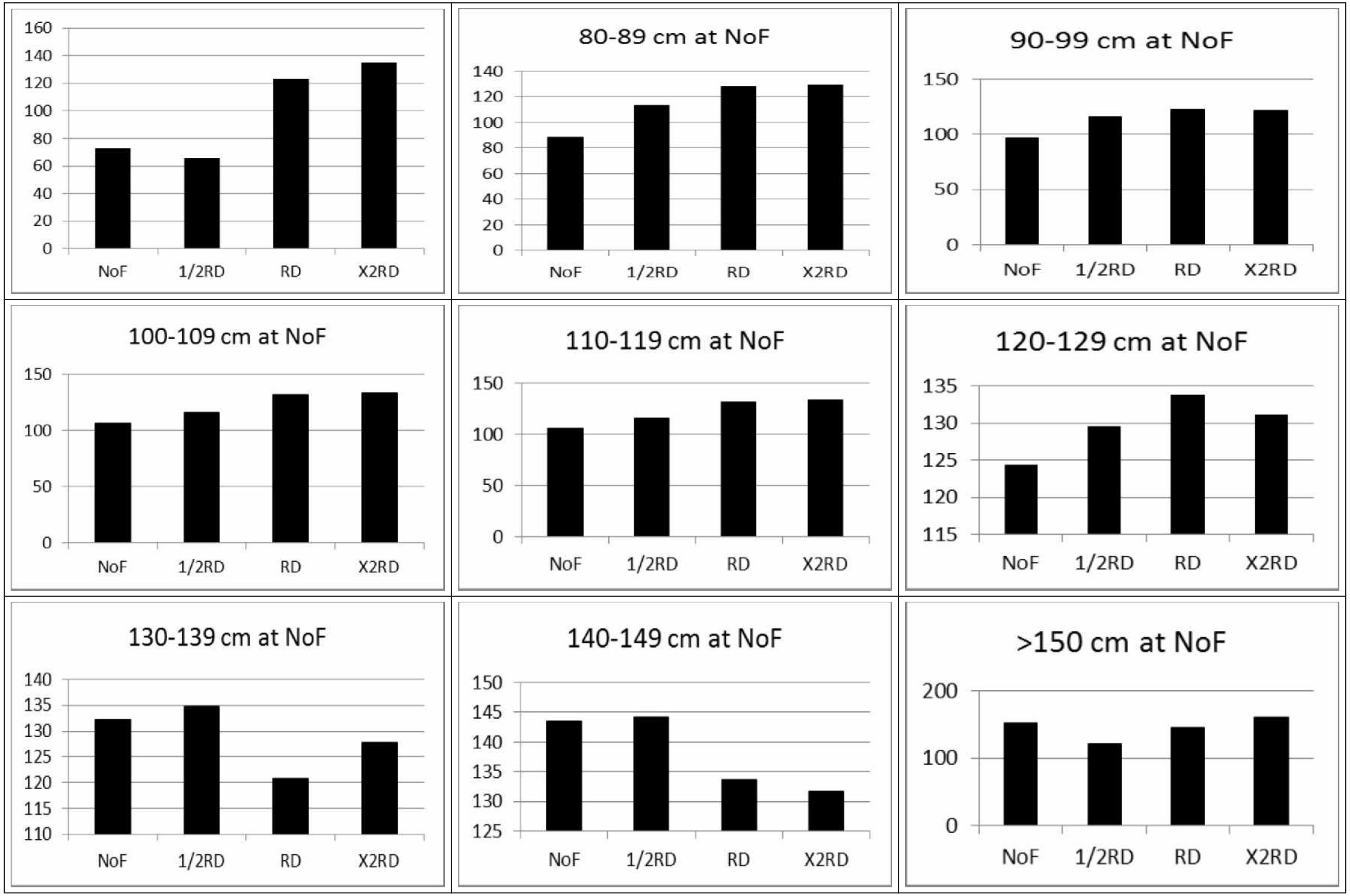
Table 2: Effect of fertilizer on plant height (cm) of evaluated traditional rice cultivars

Accession no	Name	No fert.	x1/2 RD	RD	x2 RD
3673	*Kaluhandiran*	151.93^{b}	124.08^{c}	124.63^{c}	166.98^{a}
3674	*Kirikara*	101.63^{d}	121.88^{b}	115.75^{c}	139.45^{a}
3675	*Kotathavalu I*	131.00^{d}	140.10^{b}	135.70^{c}	145.70^{a}
3676	*Dena wee*	116.45^{d}	138.43^{a}	131.88^{b}	125.65^{c}
3677	*Herath Banda*	119.35^{d}	170.43^{a}	131.83^{b}	123.58^{c}
3678	*Hondarawala*	154.38^{b}	104.80^{c}	154.18^{b}	178.18^{a}
3679	*Kottakaram*	100.90^{d}	147.30^{c}	155.33^{b}	163.95^{a}
3681	*Dandumara*	151.65^{b}	144.58^{c}	160.88^{a}	161.58^{a}
3686	*Karayal I*	144.58^{b}	150.50^{a}	143.50^{b}	150.43^{a}
3687	*Dewaredderi*	128.10^{d}	136.58^{c}	144.05^{b}	150.50^{a}
3469	*Sudu wee*	110.85^{c}	139.20^{b}	144.05^{a}	138.83^{b}
3477	*Sudu Goda wee*	119.13^{c}	151.50^{a}	147.73^{b}	151.50^{a}
3479	*Kiri Naran*	126.33^{b}	158.00^{a}	126.08^{b}	125.90^{b}
3480	*Karayal II*	114.35^{c}	121.90^{b}	135.33^{a}	137.63^{a}
3482	*Akuramboda*	114.90^{c}	133.85^{a}	126.38^{b}	90.93^{d}
3486	*Puwakmalata Samba*	119.00^{c}	131.83^{b}	141.73^{a}	97.45^{d}
3487	*Palasithari 601*	126.55^{b}	131.58^{a}	128.45^{b}	79.40^{c}
3489	*Murungakayan 3*	120.63^{a}	101.05^{d}	105.03^{c}	111.03^{b}
3490	*Murungakayan 101*	88.40^{d}	127.88^{a}	107.23^{c}	116.63^{b}
3496	*Bala Ma wee I*	120.60^{c}	119.20^{c}	125.00^{b}	129.00^{a}
3654	*Pokuru Samba*	128.58^{b}	118.63^{c}	133.55^{a}	136.08^{a}
3655	*Rata wee*	142.43^{a}	137.80^{a}	123.93^{a}	112.88^{c}
3660	*Suduru*	118.75^{c}	141.13^{a}	101.18^{d}	125.03^{b}
3658	*Ingrisi wee*	111.90^{c}	109.78^{c}	127.05^{b}	133.18^{a}
3659	*Kotathavalu II*	110.20^{d}	128.03^{a}	115.38^{c}	123.38^{b}
3653	*Kalu Karayal*	106.23^{d}	115.80^{c}	147.15^{a}	141.20^{b}
3668	*Ranruwan*	102.48^{d}	114.40^{c}	131.63^{a}	123.83^{b}
3669	*Rajes*	97.33^{c}	129.33^{b}	134.63^{a}	135.88^{a}
3670	*Madoluwa*	99.43^{b}	90.91^{c}	113.55^{a}	113.00^{a}
3671	*Suduru Samba I*	101.60^{a}	88.44^{c}	96.43^{b}	105.03^{a}
3688	*Handiran*	134.98^{b}	142.88^{a}	103.68^{d}	113.50^{c}
3691	*Gunaratna*	133.28^{b}	86.63^{d}	108.55^{c}	138.43^{a}
3661	*Polayal I*	130.10^{b}	161.60^{a}	105.55^{c}	86.45^{d}
3664	*Tissa wee*	130.65^{c}	133.40^{b}	138.55^{a}	136.88^{a}
3665	*Sudu Karayal*	117.75^{c}	135.45^{a}	121.05^{bc}	123.15^{b}
3666	*Podisayam*	110.40^{b}	81.18^{d}	116.85^{a}	101.88^{c}
3423	*Giress*	113.88^{c}	122.95^{b}	125.23^{ab}	127.33^{a}
3427	*Naudu wee*	120.53^{c}	131.73^{a}	126.33^{b}	117.20^{d}
3434	*Kokuvellai*	125.93^{d}	128.03^{c}	144.25^{a}	135.78^{b}
3463	*Karayal III*	124.90^{a}	109.60^{b}	128.23^{a}	125.13^{a}
3438	*Murunga wee*	111.85^{b}	94.33^{d}	114.95^{a}	104.56^{c}
3435	*Matara wee*	120.43^{b}	112.00^{c}	150.88^{a}	106.10^{d}
3440	*Kaharamana I*	123.15^{b}	130.55^{a}	117.40^{c}	116.13^{c}
3447	*Karabewa*	108.60^{c}	80.68^{d}	146.78^{b}	162.73^{a}
3451	*Halabewa*	99.58^{c}	131.08^{a}	132.63^{a}	123.13^{b}
3445	*Yakada wee I*	109.83^{a}	82.33^{d}	114.05^{a}	107.95^{c}
3638	*Lumbini I*	73.90^{d}	92.58^{c}	121.43^{a}	114.75^{b}
3639	*Polayal II*	79.40^{c}	79.25^{c}	111.03^{a}	92.10^{b}
3641	*Heendik wee*	73.18^{c}	65.80^{d}	122.98^{b}	134.78^{a}
3642	*Kahata Samba*	125.48^{b}	105.68^{d}	115.90^{c}	137.83^{a}

Accession no	Name	No fert.	x1/2 RD	RD	x2 RD
3645	*Muthumanikam*	106.13^{c}	138.60^{b}	143.78^{a}	147.83^{a}
3646	*Induru Karayal*	151.45^{a}	115.13^{d}	141.78^{b}	139.15^{c}
3647	*Kalu gires*	119.15^{c}	130.58^{b}	135.95^{a}	135.70^{a}
3650	*Madabaru*	98.20^{d}	145.40^{a}	135.40^{b}	102.33^{c}
3651	*Balakara*	97.15^{c}	98.50^{c}	152.60^{a}	141.28^{b}
3652	*Buruma Thavalu*	89.48^{d}	155.85^{a}	134.93^{c}	146.50^{b}
3517	*Seeraga Samba Batticaloa*	96.33^{d}	141.53^{b}	150.10^{a}	120.28^{c}
3518	*H 10*	98.50^{d}	126.18^{c}	135.95^{a}	141.83^{b}
3519	*Manchel Perunel*	113.48^{d}	143.25^{c}	166.88^{a}	173.75^{b}
3562	*Thunmar Hamara*	122.15^{c}	121.63^{c}	136.35^{b}	150.83^{a}
3567	*Dingiri Menika*	120.98^{c}	133.28^{b}	152.38^{a}	133.73^{b}
3570	*Madael*	119.83^{c}	101.60^{d}	134.43^{b}	142.78^{a}
3571	*Miti Riyan*	112.50^{c}	106.18^{d}	136.10^{a}	127.70^{b}
3572	*Suduru Samba II*	119.30^{c}	110.38^{d}	140.70^{a}	133.68^{b}
3589	*Gangala*	112.25^{c}	109.35^{c}	119.00^{b}	136.05^{a}
3588	*Heenpodi wee*	108.45^{d}	116.18^{c}	124.85^{b}	129.95^{a}
3497	*Sinnanayan 398*	92.15^{c}	155.50^{b}	91.35^{c}	163.15^{a}
3498	*Geeraga Samba*	108.48^{d}	123.63^{c}	132.80^{b}	137.83^{a}
3504	*Dik wee 328*	128.15^{bc}	124.43^{c}	134.95^{a}	130.60^{b}
3506	*MI 329*	103.38^{b}	93.15^{c}	107.70^{a}	104.58^{b}
3507	*Suwanda Samba*	107.68^{c}	130.35^{a}	129.48^{a}	124.68^{b}
3508	*Madael Galle*	113.45^{c}	102.00^{d}	129.23^{b}	137.28^{a}
3510	*Sudu wee Ratnapura*	116.53^{c}	118.00^{c}	130.15^{a}	125.15^{b}
3511	*Maha Murunga Badulla*	111.73^{c}	105.63^{d}	123.68^{b}	147.90^{a}
3514	*Madael Kalutara*	118.90^{b}	111.53^{c}	124.40^{a}	126.70^{a}
3516	*Seevalee Ratnapura*	119.45^{c}	119.95^{c}	133.08^{a}	124.18^{b}
3383	*EAT Samba*	118.88^{d}	139.70^{b}	131.00^{c}	148.20^{a}
3389	*Sirappu Paleusithri*	116.03^{c}	113.23^{c}	142.90^{a}	136.85^{b}
3394	*Muthu Samba*	106.93^{d}	134.63^{c}	143.48^{a}	137.53^{b}
3395	*Podi sudu wee*	109.28^{c}	109.20^{c}	147.03^{a}	142.43^{b}
3401	*Wanni Heenati*	99.98^{c}	145.80^{a}	106.43^{b}	145.85^{a}
3409	*BG 35-2*	98.38^{b}	100.93^{b}	105.88^{a}	107.48^{a}
3410	*BG 35-7*	98.63^{b}	88.95^{c}	105.78^{a}	100.10^{b}
3415	*BG 34-8*	96.00^{ab}	86.68^{c}	95.00^{b}	97.78^{a}
3416	*A 6-10-37*	99.08^{b}	91.33^{c}	142.83^{a}	99.50^{b}
3417	*Periamorungan*	111.28^{c}	101.98^{d}	120.23^{b}	138.95^{a}
3591	*Mudukiriel*	120.85^{b}	120.68^{b}	130.98^{a}	131.78^{a}
3594	*Suduru Samba III*	91.10^{d}	97.25^{c}	131.48^{a}	107.58^{b}
3595	*Kaharamana II*	97.95^{d}	112.15^{b}	103.95^{c}	125.63^{a}
3598	*Bala Ma wee II*	88.70^{c}	87.80^{c}	110.73^{b}	128.60^{a}
3606	*Chinnapodiyan*	89.65^{c}	80.35^{d}	130.73^{a}	98.23^{b}
3607	*Kiri Murunga wee*	117.40^{d}	137.65^{b}	132.65^{c}	141.68^{a}
3610	*Heendikki*	86.33^{c}	125.55^{b}	131.05^{a}	130.35^{a}
3612	*Jamis wee I*	118.05^{c}	141.40^{a}	122.43^{b}	102.53^{d}
3613	*Lumbini II*	108.65^{c}	143.88^{a}	136.35^{b}	136.13^{b}
3614	*Sinnanayam*	87.93^{d}	101.58^{c}	150.93^{b}	155.65^{a}
3615	*Yakada wee II*	128.70^{d}	142.60^{c}	150.78^{a}	146.05^{b}
3616	*Jamis wee II*	133.80^{b}	143.88^{a}	132.28^{b}	145.93^{a}
3550	*Bathkiri el*	129.33^{d}	166.40^{a}	155.30^{c}	162.25^{b}
3713	*Kalukanda*	122.78^{d}	170.15^{a}	137.13^{c}	165.60^{b}

DMRT groupings are given in roman letters. The same letters in the same row are not significantly differed

Changing pattern of plant height with fertilizer in different fertilizer applications



NoF: No fertilizer, 1/2RD: Half recommended dose, RD: Recommended dose, X2RD: Doubled recommended dose.

The experiment was carried out according to the randomized complete block design with four replications and 3 raws per plot with 15 cm x 20 cm plant spacing. Each raw contained 20 plants and the middle-raw-plants were considered for the data collection. The soil type of the field was low humic glay soil with low base saturation. Weed management and pest management were done to minimize the environmental effect on the final grain yield. Field was properly covered by a birds' nest to minimize the bird attack on the yield. Plant height data were collected on 80 plants in four replications. ANOVA was performed using SAS (2000) to see the significant difference among rice cultivars in fertilizer response on plant height. Rice cultivars were grouped according to plant height at no fertilizer level. Plant height was averaged in all rice cultivars in each plant-height group in four different fertilizer levels. Changing pattern of plant height with fertilizer in each plant-height group was observed.

RESULTS AND DISCUSSION

To understand the prevalence of a significant difference among different fertilizer application in individual rice cultivars in plant height, ANOVA was performed for individual rice cultivars and DMRT groupings were obtained. According to ANOVA, plant height of individual traditional rice cultivar was significantly varied with the fertilizer levels (Table 2).

None of the cultivars remained constant in plant height at the four fertilizer levels. Many rice cultivars increased the plant height with fertilizer (*eg*: *Kottakaram, Dewaredderi*). In line with this Raju and Reddy (1993), Thakur (1993), Zaman *et al.* (1995), Hari *et al*. (1997) and Behera (1998) also reported the increased plant height with fertilizer. The highest plant height was recorded by the cultivar *Hondarawala* (178.2 cm) at the x 2 RD while the lowest plant height was recorded by the cultivar *Heendik wee* (65.8 cm) at x ½ RD. *Kottakaram, Dewaredderi, Heenpodi wee, Geeraga Samba* and *Sinnanayam* cultivars increased their height linearly with the increased fertilizer applications. Different rice cultivars increased their plant height differently at four fertilizer levels. Considering which cultivars recorded the highest plant height at a specific fertilizer level; cultivar *Hondarawala* recorded the highest plant height both at no fertilizer (154.4 cm) and at x 2 RD (178.2 cm) while *Herath Banda* (170.4 cm) and *Manchel Perunel* (166.9 cm) recorded the highest plant height at x ½ RD and at RD respectively. Cultivar *Heendik wee* recorded the lowest plant height both at no fertilizer (73.2 cm) and at x ½ RD (65.8 cm). *Sinnanayan* 398 (91.4 cm) and *Palasithari* 601 (79.4 cm) cultivars recorded the lowest plant height at RD and at x2 RD respectively. Many rice cultivars like *Akuramboda*, *Puwakmalata samba* recorded the lowest plant height at x2 RD. The same results have been obtained by Gebrekidan and Seyoum (2006). Meanwhile, plant height of cultivar Rata wee remained constant at no fertilizer, x ½RD and RD and then rapidly decreased with x2 RD. Cultivar BG 35-2 and *Mudukiriel* recorded a constant plant height at no fertilizer and x½ RD and then plant height increased up to a constant level at RD and x2 RD. It was observed that at shorter plant height groups (70-119 cm), plants increased the height with increased fertilizer while in 120-129 cm plant-height group, plant height was not increased with x 2RD fertilizer level than that of the RD fertilizer level and the distribution of plant height was nearly normal (Fig.1). However, the changing pattern of plant height in all the other plant height groups (> 130 cm) was sigmoid.

It can be concluded that the elongation pattern of leaves or culms of rice plants with increased fertilizer depends on the initial plant height of rice cultivars at no fertilizer level

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