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## Dry matter production and accumulation in different plant parts of rice cultivars as influenced by irrigation regimes and systems of cultivation

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### Abstract

Alternate wetting and drying (AWD) irrigation has been widely adopted to replace continuous flooding (CF) irrigation for saving water and increasing water productivity in irrigated rice systems. There is limited information on the performance of different rice cultivars under different establishment methods. A field experiment was conducted on a clay loam soil at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR), Rajendranagar, Hyderabad, Telangana during the *kharif* seasons of 2017 and 2018. to study the “productivity and water use efficiency of rice cultivars under different irrigation regimes and systems of cultivation” The treatments consisted of two irrigation regimes Alternate wetting and drying and Saturation as main plot treatments, three establishment methods System of Rice Intensification (SRI), Drum Seeding (DS) and Normal transplanting (NTP) as sub plot treatments and four Cultivars namely DRR Dhan 42, DRR Dhan 43, MTU-1010 and NLR-34449 as sub-sub plot treatments summing up to 24 treatment combinations laid out in split-split plot design with three replications. Among the cultivars, DRR Dhan 43 registered higher dry matter production at 90 DAS/DAT and harvest as compared to other cultivars. Whereas MTU-1010 and NLR-34449 recorded on par dry matter production values at all the crop growth stages during both the years of study. However DRR Dhan 42 produced the lowest dry matter production compared to other genotypes. DRR Dhan 43 recorded higher dry matter accumulation ( $\text{g m}^{-2}$ ) in root, stem and leaves at all the crop growth stages, during both the years of the study over other cultivars.

**Keywords:** Rice, cultivars, dry matter production and accumulation, irrigation regimes and systems of cultivation

### Introduction

Rice is one of the most important cereal crops occupying second position in global agriculture and it is widely grown in India due to its wider adaptability. To safeguard and sustain the food security in India, it is quite important to increase the productivity of rice under limited resources, especially land and water. Hence, the major challenges are to produce more rice per unit amount of natural resource. As per the concepts of water foot print and virtual water to produce one kg of rice 3000 to 5000 litres of water is required. Being a water-intensive crop, cultivation of rice has been a big drain on water resources. Rice is a heavy water consumer but water for rice production is becoming scarce and expensive due to the increased demand for water from the ever growing population and industries (Choudhury *et al.*, 2014) [4]. Rainfall patterns in many areas are becoming more unreliable, with extremes of drought and flooding occurring at unexpected time. Traditional planting has been the most important and common method of crop establishment practice under irrigated lowland rice ecosystems in tropical Asia. In irrigated lowland rice which not only consumes more water but also causes wastage of water resulting in degradation of land. In recent years to tackle this problem, many methods of cultivation have been developed and one among them is System of Rice Intensification (SRI). Growth and yield characteristics of any cultivar depend on genetic and environmental factors. Among the different production factors, varietal selection at any location plays an important role. Proper crop management depends on the growth characteristics of various varieties to get maximum benefit from new genetic material. Among the different water-saving irrigation methods in rice, the most widely adopted is alternate wetting and drying (AWD).

Many of the rice cultivars vary in their performance under different systems of cultivation. Higher dry matter production per unit area is the critical prerequisite for higher yield. The amount of dry matter production partitioning depends on effective photosynthesis and respiration of crop. The total yield of dry matter is the total amount of dry matter produced and less the photosynthates used for respiration. Finally, the manner in which the net dry matter produced is distributed among the different parts of the plant, which determine magnitude of the economic yield (Arnon, 1972) [3]. There was a progressive and conspicuous increase in root, stem and leaf dry matter accumulation ( $\text{g m}^{-2}$ ) with the advancement of crop growth stage up to 90 DAT.

### Material and Methods

The field experiment comprises of 24 treatment combinations conducted at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR) farm, Rajendranagar, Hyderabad during the *kharif* seasons of 2017 and 2018. located at 17°19' N latitude, 78°23' E longitude and an altitude of 542.3 m above mean sea level, It represents the Southern Telangana agro-climatic zone of Telangana state. According to Troll's climatic classification, it falls under semi-arid tropics (SAT). During the crop growth period, a total rainfall of 990.4 mm was received in 50 rainy days in the first year and 375.6 mm in 26 rainy days in the second year. The weekly mean maximum and minimum temperature on an average of 30.4 °C, 31.2 °C and 19.9 °C, 18.2 °C were recorded during 2017 and 2018 respectively. The treatments consisted of two irrigation regimes Alternate wetting and drying and Saturation as main plot treatments, three

establishment methods System of Rice Intensification (SRI) with spacing of 25 cm x 25 cm, Drum Seeding (DS) with spacing of 20 cm x 10 cm and Normal transplanting (NTP) with spacing of 20 cm x 15 cm as sub plot treatments and four Cultivars namely DRR Dhan 42, DRR Dhan 43, MTU-1010 and NLR-34449 as sub-sub plot treatments laid out in split-split plot design with three replications. The area of each gross plot was 7 x 3 m<sup>2</sup>. Seedlings were transplanted with an average of one seedling per hill in the SRI method of planting. FYM at @ 10 t ha<sup>-1</sup> was uniformly applied to all the plots before final puddling and levelling. The recommended dose of phosphorus @ 60 kg P<sub>2</sub>O<sub>5</sub> kg ha<sup>-1</sup> as single super phosphate (SSP) was applied to all the treatments uniformly as basal and potassium @ 40 kg K<sub>2</sub>O ha<sup>-1</sup> as muriate of potash (MOP) was applied in two splits, 75 per cent as basal and the remaining 25 per cent at 75 DAS/DAT. Recommended dose of nitrogen (120 kg ha<sup>-1</sup>) was applied through urea in three splits, 50 per cent as basal, 25 per cent at 50 DAS/DAT and the remaining 25 per cent at 75 DAS/DAT.

### Results and Discussion

#### Effect on dry matter production and accumulation

Increase in average total dry matter production of rice was rather slow up to 30 DAS there after it increased linearly up to 90 DAS and further, it continued to increase until maturity but it was at a diminishing rate in both the years of study (Table.1 and Fig.1) there was a Progressive increase in dry matter accumulation ( $\text{g m}^{-2}$ ) in different plant parts *viz.* root, stem and leaves with the advancement of crop growth stage up to 90 DAS/DAT (Fig.2).

**Table 1:** Dry matter production of rice as influenced by different irrigation regimes, systems of rice cultivation and cultivars during *kharif* 2017 and 2018

Treatments	Dry matter production (Kg ha <sup>-1</sup> )											
	30 DAS/DAT			60 DAS/DAT			90 DAS/DAT			At harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
<b>Irrigation regimes (I)</b>												
I <sub>1</sub> : AWD	198	204	201	601	620	611	4209	4343	4276	11022	11373	11198
I <sub>2</sub> : Saturation	196	185	191	555	559	557	3864	3932	3898	10164	10327	10246
SEm ±	2.2	3.1	2.6	14.1	19.5	16.8	117.9	135.6	126.7	290.8	315.3	303.0
C.D (P = 0.05)	NS	NS	NS	41	58	50	342	407	375	855	986	921
<b>Systems of rice cultivation (S)</b>												
S <sub>1</sub> : SRI	207	225	215	621	682	651	4348	4779	4564	11385	12514	11950
S <sub>2</sub> : DS	202	192	197	613	583	598	4293	4086	4190	10242	10700	10971
S <sub>3</sub> : NTP	184	168	176	560	509	534	3921	3565	3743	9270	9337	9803
SEm ±	5.6	6.9	5.7	17.2	20.9	17.4	120.6	146.7	122.3	315.8	384.3	320.2
C.D (P = 0.05)	18	22	19	56	68	56	393	478	398	1029	1036	1044
<b>Cultivars (C)</b>												
C <sub>1</sub> : DRR Dhan 42	183	185	184	556	541	548	3892	4044	3968	9193	9851	9522
C <sub>2</sub> : DRR Dhan 43	205	198	201	603	612	607	4364	4276	4320	11427	11670	11548
C <sub>3</sub> : MTU-1010	195	186	190	601	563	582	4351	3945	4148	10948	11150	11049
C <sub>4</sub> : NLR-34449	190	187	188	571	580	575	4142	4111	4126	11394	10330	10862
SEm ±	6.0	5.2	4.5	18.2	15.7	13.7	127.5	110.4	96.1	334.0	289.3	251.6
C.D (P = 0.05)	17	14	12	51	44	39	362	314	273	949	823	886
Interactions	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

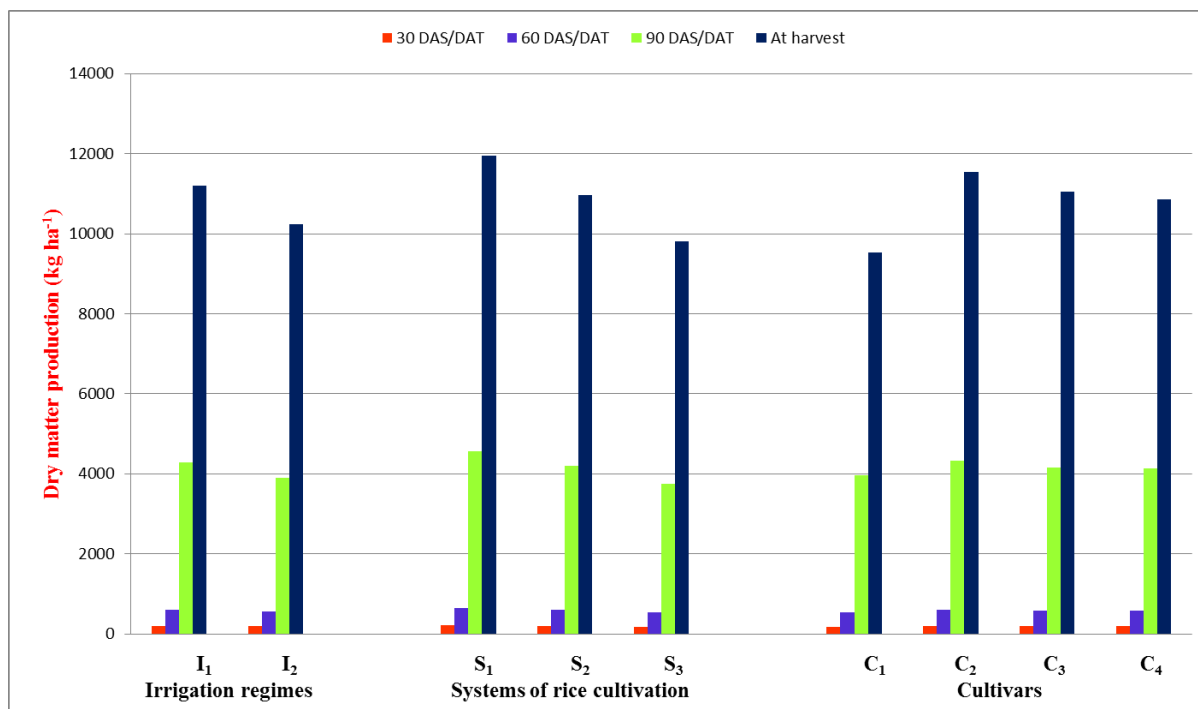
#### Effect of irrigation regimes

Alternative wetting and drying method of irrigation recorded significantly higher DMP at all the growth stages of rice (60, 90 DAS/DAT and at harvest) except at 30 DAS/DAT during both 2017 and 2018 as compared to saturation. The dry matter production in AWD was 601 and 620 kg ha<sup>-1</sup> at 60 DAS/DAT, 4209 and 4343 kg ha<sup>-1</sup> at 90 DAS/DAT and 11022 and 11373 kg ha<sup>-1</sup> at harvest during 2017 and 2018 respectively as compared to saturation was 555 and 559 kg ha<sup>-1</sup> at 60

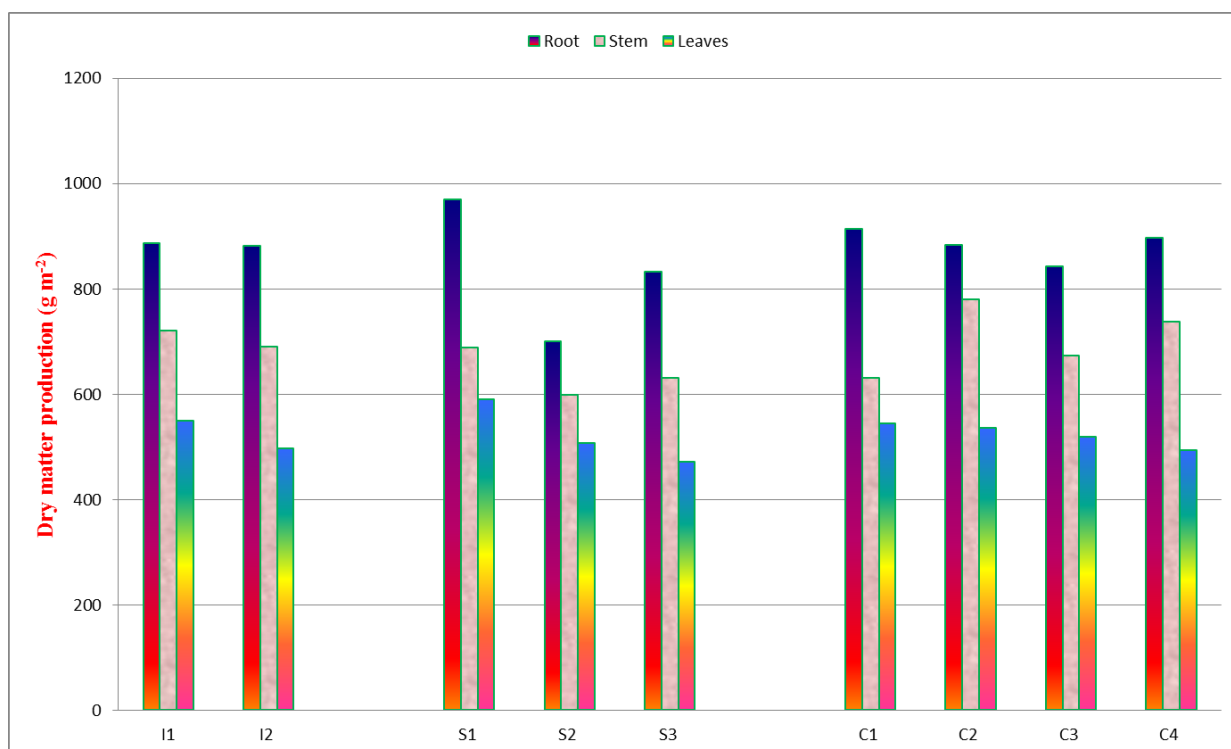
DAS/DAT, 3864 and 3932 kg ha<sup>-1</sup> at 90 DAS/DAT and 10164 and 10327 kg ha<sup>-1</sup> at harvest during 2017 and 2018 respectively (Table 1 and Fig.1). It is because of rapid growth by maintenance of adequate wetness with intermittent water to crop that maintained good plant roots and varied metabolic processes that perform higher nutrient mobilization. These results were also in line with the observations made by Lu *et al.* (2000) [8], Kumar *et al.* (2013) [7] and Chowdhury *et al.* (2014) [4].

There was no significant difference in dry matter accumulation ( $\text{g m}^{-2}$ ) of root, stem and leaves among the irrigation regimes during both the years of study (Fig. 2). Relatively higher dry matter accumulation ( $\text{g m}^{-2}$ ) of root was observed in AWD at 30, 60, 90 DAS and harvest during the

both years. It might be due to increased root oxidation activity and root source cytokinins in intermediate irrigation in AWD. This finding was in conformity with the findings of Armstrong and Webb (1985) [2], who observed the possibility of extended growth of rice roots under influence of oxygen.



**Fig 1:** Dry matter production ( $\text{kg ha}^{-1}$ ) of rice as influenced by different irrigation regimes, systems of rice Cultivation and cultivars (pooled means of *kharif* 2017 and 2018)



**Fig 2:** Dry matter production ( $\text{g m}^{-2}$ ) and partitioning in rice as influenced by different irrigation regimes, establishment methods and cultivars (pooled means of *Kharif* 2017 and 2018)

### Effect of systems of cultivation

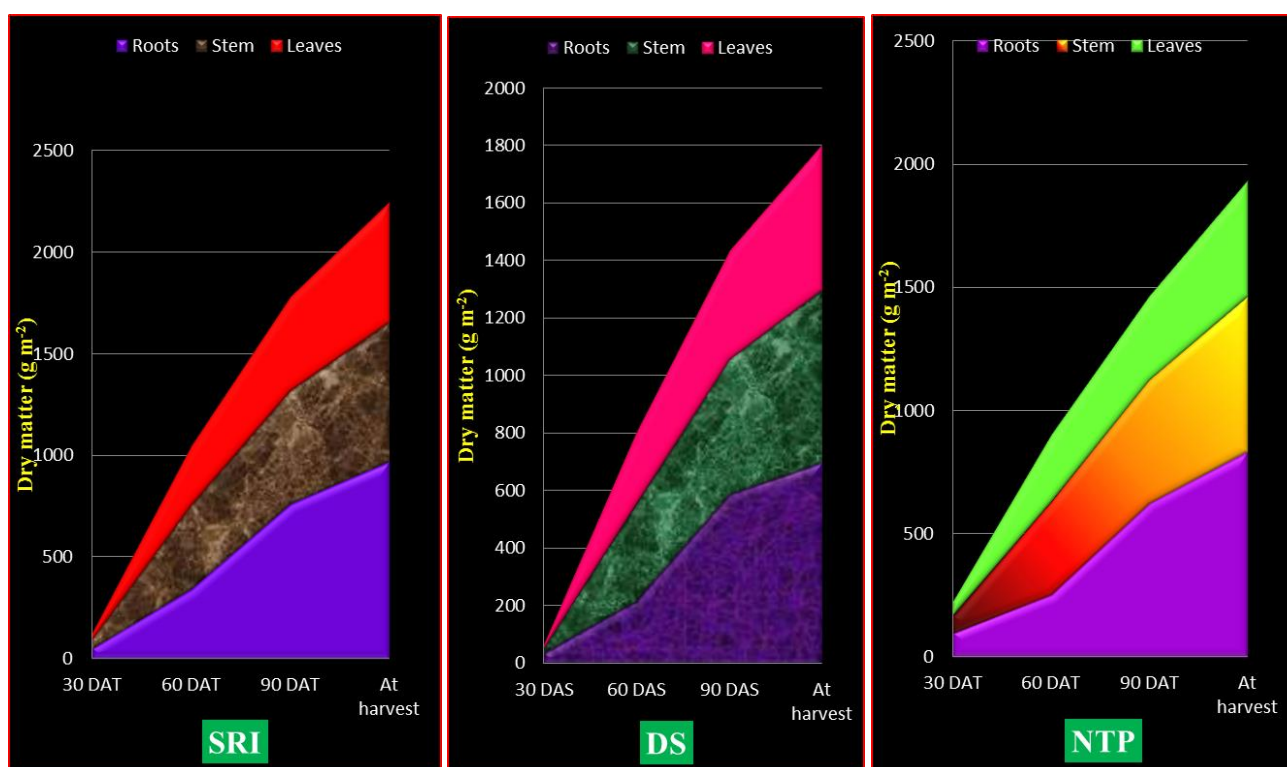
Among the different systems of rice cultivation, SRI recorded significantly higher DMP as compared to normal transplanting, however it was comparably at par with drum seeding at all the growth stages. Significantly the higher DMP

was noticed in SRI at 30, 60, 90 DAS/DAT and at harvest (215, 651, 4564 and 11950  $\text{kg ha}^{-1}$  respectively in pooled means of both 2017 and 2018) as compared to normal transplanting (176, 534, 3743 and 9803  $\text{kg ha}^{-1}$  respectively in pooled means of both 2017 and 2018) and it was at par with

drum seeding (197, 598, 4190 and 10971 kg ha<sup>-1</sup> respectively in pooled means of both 2017 and 2018) (Table.1 and Fig.1). Higher dry matter production of the above treatment may be attributed to better establishment of seedlings and more number of tillers m<sup>-2</sup>. Significantly lower dry matter was recorded with drum seeding at all the stages except at 30 DAS. Lowest dry matter production in drum seeding method may be attributed to non-uniform plant stand and less number of tillers m<sup>-2</sup>. This was supported by Anbumani *et al.* (2004)<sup>[1]</sup>. The higher dry matter production in SRI method was attributed to planting of young seedling at shallow depth in wider spacing and cono-weeding which leads to taller plants, higher leaf area, better root growth, profuse and strong tillers with higher crop growth rate. Increased shoot: root ratio and production of more number of tillers hill<sup>-1</sup> under wider spacing were the reasons for increased dry matter production (Rajesh and Thanunathan, 2003)<sup>[11]</sup>. In addition to that

conoweeding increased the soil aeration which enhanced availability of dissolved oxygen in irrigation water thereby increasing shoot: root ratio and LAI and subsequently increasing dry matter production (Uphoff, 2002)<sup>[15]</sup>. The results obtained in this investigation are in conformity with the findings of Hussain *et al.* (2012)<sup>[5]</sup>, Sridevi and Chellamuthu (2012)<sup>[14]</sup> and Rajendran *et al.* (2013)<sup>[10]</sup>.

Dry matter accumulation in different plant parts was superior with system of rice intensification over drum seeding and NTP during both the years of study at all the growth stages (Fig. 3). Less interplant competition would have enabled the plants to have more physiological activity. In square planting with wider spacing more soil area was available for foraging thus leading to improved root growth in SRI. This is in accordance with the observations of Jayakumar *et al.* (2005)<sup>[6]</sup>, Priyanka *et al.* (2013)<sup>[9]</sup> and Rani and Sukumari (2013)<sup>[12]</sup>.



**Fig 3:** Comparison between the dry matter production and partitioning at different growth stages into root, stem and leaf under SRI, DS and NTP methods (pooled means of *Kharif* 2017 and 2018)

### Effect of rice Cultivars

Among the different varieties, DRR Dhan 43 cultivar recorded significantly higher dry matter production at 30 DAS/DAT (205, 198 and 201 kg ha<sup>-1</sup> during 2017, 2018 and in pooled means, respectively) over other cultivars. However MTU-1010 cultivar was at par with DRR Dhan 43 at 30 DAS/DAT. At 60, 90 DAS/DAT and harvest significantly DMP was recorded with DRR Dhan 43 cultivar (607, 4320 and 11548 kg ha<sup>-1</sup> respectively in pooled means of both 2017 and 2018) than other cultivars. However MTU-1010 and NLR-34449 cultivars were recorded on par DMP values with DRR Dhan 43. While DRR Dhan 42 cultivar recorded the lowest DMP compared to other cultivars at all the growth stages during 2017 and 2018. difference in DMP among the cultivars and the lower values of DRR Dhan 42 may be due to genetical inherent character of the varieties. Similar findings were also line up with Sharath (2017)<sup>[13]</sup> and Vijay (2018)<sup>[16]</sup>. Among the cultivars, dry matter accumulation (g m<sup>-2</sup>) in root, stem and leaves at all the crop growth stages in both the years

of study and in pooled means was statistically non-significant except DRR Dhan 43 where recorded significantly higher dry matter accumulation (g m<sup>-2</sup>) during both the years of the study over other cultivars.

### Effect of interaction

The interaction was statistically non significant among irrigation regimes, systems of rice cultivation and rice cultivars on dry matter production and accumulation at all the growth stages during both the years of study.

### Conclusion

Results revealed that the increase in average total dry matter production of rice was rather slow up to 30 DAS there after it increased linearly up to 90 DAS and further, it continued to increase until maturity but it was at a diminishing rate in both the years of study. There was progressive increase in dry matter accumulation (g m<sup>-2</sup>) in different plant parts *viz.* root, stem and leaves with the advancement of crop growth stage

up to 90 DAS/DAT under semi arid tropical climatic condition in clay loam soil at Indian Institute of Rice Research (IIRR), Rajendra nagar, Hyderabad.

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