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Yield and Physiological Attributes of Upland Rice as Influenced by Irrigation Scheduling and Live Mulching with Cowpea

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A field experiment was carried out in the farmer's field, Peringammala, Kalliyoor, Thiruvananthapuram during the *Virippu* 2017 to study the effect of irrigation scheduling and live mulching with cowpea on physiological attributes and yield of upland rice. Results revealed that irrigation at 3 cm depth at 10 mm CPE (I_1),live mulching with cowpea (M_2) and their interaction (I_1M_2) registered the highest grain and straw yield. The treatment I_1 resulted in 92.4 per cent increase in grain yield compared to rainfed control (I_7). The reduction in yield at wider irrigation treatment might be due to the severe moisture stress experienced especially during tillering and panicle initiation stage. Irrigation had a favourable influence on physiological characters like relative leaf water content and proline content. The frequent irrigation treatment (I_1) recorded the highest relative leaf water content (80.32 per cent) while the rainfed treatment (I_7) recorded the highest proline content (0.94 µmol g^{-1} FW). Thus for getting higher yield in upland rice, irrigation at 3 cm depth at 10 mm CPE and live mulching with cowpea can be recommended.

Key words: Upland rice, Irrigation, Live mulching, Prolinecontent, Relative leaf water content

Upland rice is mainly grown as a rainfed crop in the first crop season (*Virippu*) of Kerala. Frequent failure of monsoons has created moisture stress in soil during critical periods of tillering, panicle initiation, flowering and grain filling which can adversely affect the growth and yield of upland rice.Among the different abiotic forms of stress, drought is a major limiting factor regarding crop yields and productivity around the world.Water deficit stress is primarily caused by drought which can be defined as a period of abnormally dry weather, results in soil-water deficit and subsequently plant-water deficit (Bray, 2001). Drought is considered as the single most devastating environmental stress which decreases crop productivity more than any other environmental stress.Proline acts as osmolytes and its accumulation contributes to better performance and drought tolerance (Vajrabhaya*et al.*, 2001). Changes in the concentration of proline have been observed in rice exposed to drought stress (Maisura*et al.*, 2014). Proline accumulation is high in drought resistant traits, suggesting that this metabolic pathway is important in response to drought stress.Besides acting as an excellent osmolyte, proline plays three major roles during stress, i.e., as a metal chelator, an antioxidative defence molecule and a signaling molecule (Hayat *et al.,* 2012). So in order to avoid moisture stress condition, a proper irrigation scheduling along withlive mulching of cowpea for improvement of yield in upland rice.

Material and Methods

The field experiment was laid out in the farmer's field, Peringammala, Kalliyoor, Thiruvananthapuram during the *Virippu* 2017 to study the effect of irrigation scheduling and live mulching with cowpea on physiological attributes and yield of upland rice. Prathyasa (MO 21) was used as the experimental material. The experiment was conducted with 14 treatment combinations involving seven irrigation treatments (I_1 -irrigation at 3 cm depth at 10 mm CPE, I_2- irrigation at 3 cm depth at 20 mm CPE, I_3- irrigation at 3 cm depth at 30 mm CPE, I_4- irrigation at 2 cm depth at 10 mm CPE, I_5- irrigation at 2 cm depth at 20 mm CPE, I_6 - irrigation at 2 cm depth at 30 mm CPE and I_7- rainfed control) and two mulching treatments (M_1- no live mulching, M_2- live mulching with cowpea) with three replications in randomized block design. There were fourteen interaction treatments I_1M_1, I_1M_2, I_2M_1, I_2M_2, I_3M_1, I_3M_2, I_4M_1, I_4M_2, I_5M_1, I_5M_2, I_6M_1, I_6M_2, I_7M_1 and I_7M_2. The soil of the experimental site was sandy clay loam, strongly acidic, medium in organic carbon, low in available N and high in available P and K. Farm yard manure @ 5 t ha^{-1} was added to all the plots uniformly. The fertilizer recommendation of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O ha^{-1} was followed in all plots.

A total rainfall of 679 mm was recorded during the cropping period. One pre sowing irrigation was given to the field on the day before sowing with 10 mm depth of water and rice seeds were dibbled. A common irrigation was also given to all plots with 10 mm depth of water to ensure uniform establishment of seedlings. The differential irrigation according to treatments was also given. The evaporation readings from a USWB Class A open pan evaporimeter were recorded daily and whenever the cumulative pan

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evaporation values attained the treatment values, irrigation was given to the concerned plots with 20 mm and 30 mm depth of water as per treatments. The irrigation water was measured using a water meter. Seeds of upland rice variety Prathyasa were dibbled at 85 kg ha^{-1} at a spacing of 20 cm x 10 cm and one row of cowpea variety,Aiswarya was sown between two rows of rice in mulched treatment plots. In unmulched treatment cowpea seeds were not sown. In mulched plots cowpea was incorporated in to the field at six weeks active growth stage.The observations on physiological attributes like relative leaf water content and proline content were recorded. Grain and straw yields were also recorded.

Results and Discussion

Physiological attributes

In the present study, the irrigation treatment I_1 (irrigation at 3 cm depth at 10 mm CPE) recorded the highest relative leaf water content (RLWC) (Table1).

Table 1. Effect of irrigation and mulching on relative leaf water and proline contents of upland rice

Treatments	RWC (%)	Proline content (μ mol g^{-1} FW)
Irrigation (I)		
I_1	80.32	0.42
I_2	80.18	0.44
I_3	79.47	0.45
I_4	79.48	0.43
I_5	79.01	0.47
I_6	77.36	0.73
I_7	72.69	0.94
SEm (±)	1.75	0.04
CD (0.05)	5.088	0.080
Live Mulching (M)		
M_1	77.56	0.55
M_2	79.16	0.56
SEm(±)	0.93	0.02
CD (0.05)	NS	NS

RLWC is an expression of internal water status in plant tissues. High moisture content in the soil due to frequent irrigation resulted in greater absorption of water by roots and thereby maintained high water content in the plant tissues. This is in conformity with the findings of Sheela (1993). Though not significant, mulching with cowpea maintained high RLWC. The higher water holding capacity in the soil due to mulching coupled with improved physical properties of the soil helped the plant to extract more water in the soil leading to high RLWC. This is in agreement with the findings of Kumar (2016) and Ranjini (2002).

The rainfed treatment (I_7) recorded the highest proline content (Table 1, Fig. 1). Proline accumulation in the leaves of water stressed plants may play a role as stress indicator. It is one of the most important osmolytes that accumulate in plants experiencing drought stress (Yoshiba*et al.,* 1997). Proline accumulation under stress supplied energy for survival and growth and thereby helped the plants to tolerate stress condition (Kumar *et al*., 2011).

Table 2. Effect of irrigation and mulching on grain and straw yield (kg ha^{-1})

Treatments	Grain yield	Straw yield
Irrigation (I)		
I_1	2949	3100
I_2	2597	2899
I_3	2287	2432
I_4	2780	2984
I_5	2442	2661
I_6	2057	2302
I_7	1533	2083
SEm (±)	18.34	35.65
CD (0.05)	53.344	103.658
Live Mulching (M)		
M_1	2318	2584
M_2	2438	2690
SEm(±)	9.81	19.06
CD (0.05)	28.517	55.407

Proline accumulation might promote plant damage repair ability by increasing antioxidant activity during drought stress. In plants under water stress, proline content increases more than other amino acids, and this effect has been used as a biochemical marker to select varieties aiming to resist to such conditions (Fahramand*et al.,* 2014).

Table 3. Interaction effect of irrigation and mulching on grain and straw yield

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
I X M interaction		
I_1M_1	2840	3058
I_1M_2	3057	3143
I_2M_1	2578	2843
I_2M_2	2617	2955
I_3M_1	2255	2392
I_3M_2	2319	2471
I_4M_1	2720	2904
I_4M_2	2840	3063
I_5M_1	2356	2608
I_5M_2	2529	2713
I_6M_1	1986	2238
I_6M_2	2127	2366
I_7M_1	1490	2047
I_7M_2	1575	2119
SEm (±)	25.94	50.42
CD (0.05)	75.436	NS

Yield

The irrigation treatment I_1 (irrigation at 3 cm depth at 10 mm CPE) recorded the highest grain yield (2949 kg ha^{-1}) and straw yield (3100 kg ha^{-1}) which were significantly superior to other irrigation treatments. The results showed that (Table 2) the reduction in yield at wider irrigation treatment might be due to the severe moisture stress experienced especially during tillering and panicle initiation stage. It was reported that yield reduction under moisture stress was mainly attributable to the higher number of unfilled grains. Soil wetness favourably influenced

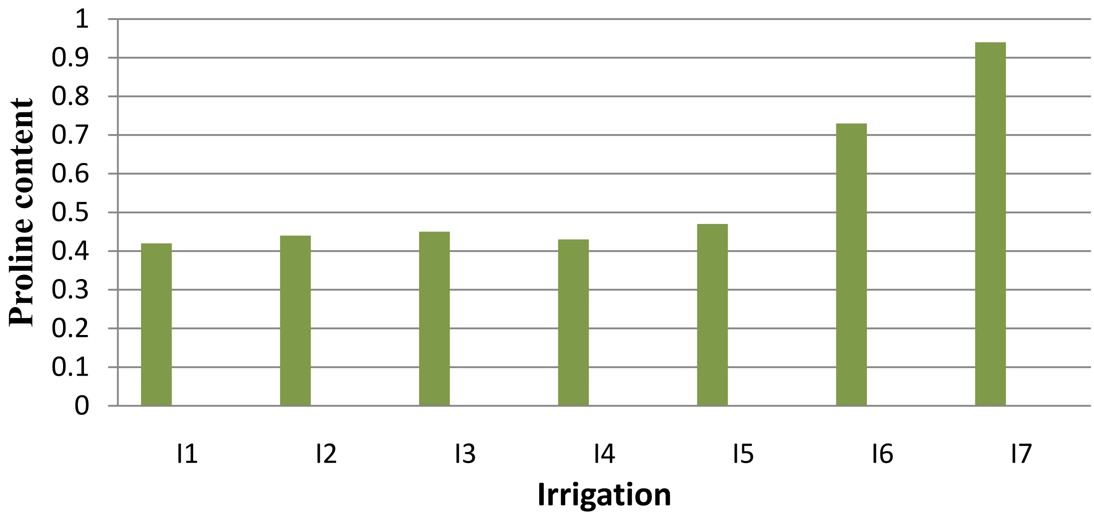

Fig. 1. Effect of irrigation on proline content of upland rice

the yield attributes and there by yield.Grain and straw yield were favourably influenced by M_2 (live mulching with cowpea).Yield increase by mulching was due to high moisture content, increased microbial activity, higher organic matter status and nutrients mobility (Chonbeck and Evanylo, 1998). Combined application of irrigation and mulching favourably influenced the grain yield (Table 3). The treatment combination I_1M_2(irrigation at 3 cm depth at 10 mm CPE and live mulching with cowpea) recorded the highest grain yield. The increased soil moisture content due to deeper and frequent irrigation combined with high water holding capacity of the mulches helped in maintaining uniform moisture supply throughout the crop period and resulted in high nutrient uptake and dry matter production and this could have manifested in higher grain yield. But under rainfed treatment, due to moisture stress yield was found to be lower.

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