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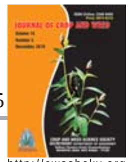

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Influence of seed hydropriming on establishment of upland rice, *Oryza sativa* L. in coconut garden

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ABSTRACT

Hydropriming is a promising cost effective strategy that aids farmers to attain a better yield by sorting out the challenges of poor stand establishment. An experiment was conducted at Coconut Research Station, Balaramapuram, Thiruvananthapuram, Kerala during kharif 2018 in a Randomised Block Design with ten treatments in three replications. The objective of the study was to find out the most cost-effective crop establishment technique for upland rice and to assess its impact on growth and yield of rice. The treatments comprised of line sowing dry and hydroprimed seeds @ 60 kg ha^{-1}, broadcasting dry, hydroprimed and pre-germinated seeds @ 80 and 100 kg ha^{-1} and thomba method of planting at two different spacing (15× 10 cm and 20 × 10 cm). Broadcasting hydroprimed seeds at 80 kg ha^{-1}recorded significantly maximum number of tillers (562.33) at harvest and registered high values for the yield attributes; the highest grain yield ha^{-1}and B:C ratio. The study revealed that broadcasting hydroprimed seeds @ 80 kg ha^{-1} with a grain yield of 3900.7 kg ha^{-1} and B: C ratio of 1.72 is the cost-effective crop establishment technique for upland kharif rice in coconut garden.

Keywords: Broadcasting, dry seeds, hydroprimed seeds, line sowing and thomba method of planting

Rice is life for millions of people all over the world. It provides 60 to 70 per cent of total calorie requirement and hence considered as the most important staple food. Upland rice production system is considered as one of the most sustainable alternative for enhancing rice production (Mondo *et al*., 2016). Hydropriming is a promising strategy that permits direct field sowing and improves the physiological performance of seeds and helps to resolve the challenge of poor stand establishment (Farooq *et al.*, 2011). Being a principal pre-sowing seed enhancement technique, hydropriming shortens the time gap between seed sowing and seedling emergence. Hydropriming possesses great potential to improve emergence and stand establishment under a wide range of field conditions (Phill, 1995). Hydro priming involves partial hydration to a point where germination-related metabolic processes begins but radical emergence does not occur (Farooq *et al.*, 2006). He also added that for rice sown in aerated soils, seed priming enhances seedling emergence, grain quality and yield. Seed rate has a great impact on plant density and the competitiveness of the crop stand, tillering time to maturity and yield. Low plant density and improper sowing method are the most important factors of agronomic constraints for obtaining higher yields and have a positive influence on the yield of rice.

Lack of appropriate stand establishment technique is the main drawback in the production of upland rice. Manual dibbling of dry seeds in lines is the crop establishment technique commonly adopted by the farmers. It requires huge labour. Because of high labour cost, acute labour shortage and low productivity, the farmers are reluctant to raise upland rice. Within this context, the influence of hydropriming as an emerging technique is to be evaluated in order to understand its effect on growth and yield attributes of upland rice. Also a complete understanding of the crop behaviour towards different seed rate and establishment methods is imperative for enhancing the growth, yield and economic returns of upland rice. With this back ground, the present study was carried out to find out the most cost effective crop establishment technique for upland rice and to assess its impact on growth and yield of rice.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* 2018 (May to September 2018) at Coconut Research station (CRS), Balaramapuram, Thiruvananthapuram, Kerala. The site was located at 8°22'52" North latitude and 77°1' 47" East longitude and at an altitude of 9 m above mean sea level. A warm humid climate prevailed over the experimental site. The data on daily weather parameters like mean temperature, relative humidity (RH), rainfall and evaporation were noted from the Class B Agromet observatory attached to the site. The rainfall received during the crop season was 952.3 mm. The soil texture was sandy loam with acidic pH (4.6). The soil had medium organic carbon (0.79%), N (301.50 kg ha^{-1}), P (21.10 kg ha^{-1}) and low K (93.07 kg ha^{-1}) status.

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The experiment was laid out in Randomised Block Design with ten treatments in three replications. The treatments included, line sowing dry seeds 60 kg ha^{-1} (T_1), line sowing hydroprimed seeds 60 kg ha^{-1} (T_2), broadcasting dry seeds 80 kg ha^{-1} (T_3), broadcasting hydroprimed seeds 80 kg ha^{-1} (T_4), broadcasting dry seeds 100 kg ha^{-1} (T_5), broadcasting hydroprimed seeds 100 kg ha^{-1} (T_6), broadcasting pre-germinated seeds 80 kg ha^{-1} (T_7), broadcasting pre-germinated seeds 100 kg ha^{-1}(T_8), thomba method of planting 15 x 10 cm (T_9) and thomba method of planting 20 × 10 cm (T_{10}). For hydropriming, the seeds were soaked in water for 16 hours and then shade dried to the initial moisture content. In thomba method of planting, a mat nursery was prepared and seeds were sown by broadcasting. Fifteen days old seedlings from the nursery were separated and planted at 3 seedlings $hill^{-1}$ in the main field. Line sowing was carried out at a spacing of 20cm between rows. Dried cowdung (5 t ha^{-1}) was applied uniformly to all the plots along with the final ploughing. Fertilizers were applied at 90:30:45 kg NPK ha^{-1}. N and K were applied in three equal splits at 15, 35 and 55 days after sowing (DAS) and entire P as basal. The crop was raised purely under rainfed condition. During non-rainy periods irrigation was given to avoid moisture stress. The data were analysed statistically using ANOVA and the treatment means were compared at 5 per cent probability.

RESULTS AND DISCUSSION

The growth parameters, *viz*., number of hills m^{-2}, plant height, number of tillers m^{-2} and dry matter production (DMP) were significantly influenced by seed priming and seed rate (Table 1, 2).The number of hills m^{-2} recorded the highest in broadcasting hydroprimed seeds at a seed rate of 100 kg ha^{-1}.The effect of hydropriming on different aspects of seed germination and emergence attributed to this increase. Hydropriming treatments improved germination percentage and the seed vigour index which appeared to be related to earlier and uniform emergence and subsequent seedling growth. Khaliq *et al*. (2015) reported an enhanced activity of enzymatic antioxidants like superoxide dismutase, peroxidase and glutathione peroxidase in primed seeds by which lipid peroxidation activity decreased during germination and caused accelerated germination and increased the percentage resulting in better and earlier establishment of seedlings.

Broadcasting hydroprimed seeds 80 and 100 kg ha^{-1} each (T_4 and T_6) recorded higher number of tillers. At 40 and 60 DAS, a marked increase in the number of tillers m^{-2} was noted among all the treatments. The seed water content absorbed during hydropriming was crucial for initiating the chain of biochemical events required for early synchronised germination in primed seeds which was evident by improved membrane permeability, high activity of catalase and more integrated chloroplast and mitochondria in primed seeds. The primed seeds germinated faster than unprimed seeds when placed in an appropriate germination environment.

Plant height was significantly influenced by establishment techniques and broadcasting hydroprimed seeds (T_4 and T_6) recorded taller plants at all stages and this might be due to the early, uniform and vigorous seedlings that gave a stronger and energetic start to the plants resulting in good plant growth. In rice seeds, the metabolic process related to α-amylase activity is initiated by water absorption during seed priming and is preserved in the seed while drying after priming (Ando and Kobata, 2002).

Higher dry matter production in hydroprimed treatments was also attributed by higher number of hills m^{-2} and tillers m^{-2}. Farooq *et al.* (2006) observed that broadcasting seeds at a higher seed rate increased the plant population which also contributed for the higher total dry matter production at harvest and also for rice sown in aerated soils, seed priming enhances seedling emergence, grain quality and yield. The lowest DMP was observed with thomba method of planting 20 × 10 cm (T_{10}) at all stages of observation.

The yield attributes such as number of panicles m^{-2}, panicle length, panicle weight, number of filled grains $panicle^{-1}$ and sterility percentage were influenced significantly by hydropriming and seed rate (Table 3).The better production of yield attributes particularly number of panicles m^{-2} and filled grains $panicle^{-1}$ resulting from the better expression of growth attributes like number of tillers m^{-2} and a better availability and uptake of nutrients might be the reasons for an increased grain yield in treatment hydroprimed treatments. Hydroprimed treatments resulted in increased number of panicles m^{-2} owing to their healthier and more vigorous seedlings as indicated by improved leaf area index and photosynthate assimilation.

The better establishment in primed seeds along with the other benefits like better drought tolerance, better weed competition, early flowering resulted in reduced time to maturity and higher grain yield (Kaur *et al.*, 2005). Du and Tuong (2002) concluded that when rice is seeded in very dry soil (near wilting point), priming increased plant density, final tiller number and grain yield. In drought prone areas, seed priming can reduce the need for using high seed rate.

The results pertaining to sterility percentage was the lowest in broadcasting hydroprimed seeds at 80 kg ha^{-1} (T_4). The improved nutrients, photoassimilates and moisture supply in plants arising from primed seeds lead

Table 1: Effect of establishment techniques on hills and tillers m^{-2}

Treatments	Hills m^{-2} 20 DAS/ 15 DAT	Number of tillers m^{-2} 40 DAS/ 25 DAT	60 DAS/ 45 DAT	At harvest
Line sowing dry seeds 60 kg ha^{-1} (T_1)	63.67	495.68	534.00	497.00
Line sowing hydroprimed seeds 60 kg ha^{-1} (T_2)	72.00	497.63	550.33	508.33
Broadcasting dry seeds 80 kg ha^{-1} (T_3)	62.33	479.12	542.00	499.00
Broadcasting hydroprimed seeds 80 kg ha^{-1} (T_4)	72.67	559.76	585.33	562.33
Broadcasting dry seeds 100 kg ha^{-1} (T_5)	61.33	482.13	557.43	535.33
Broadcasting hydroprimed seeds 100 kg ha^{-1} (T_6)	79.33	522.33	609.12	514.00
Broadcasting pre-germinated seeds 80 kg ha^{-1} (T_7)	68.33	454.43	504.00	500.67
Broadcasting pre germinated seeds 100 kg ha^{-1} (T_8)	67.00	439.63	458.68	446.68
Thomba method of planting 15 cm x10 cm (T_9)	60.33	377.00	486.00	502.67
Thomba method of planting 20 cm x10 cm (T_{10})	50.67	355.38	421.65	404.33
SEm (±)	**2.82**	**12.74**	**10.16**	**8.53**
LSD (0.05)	**8.53**	**38.22**	**30.50**	**25.59**

Table 2: Effect of establishment techniques on plant height and DMP

Treatments	Plant height (cm)			DMP (kg ha^{-1})		
	40 DAS/ 25 DAT	60 DAS/ 45 DAT	At harvest	40 DAS/ 25 DAT	60 DAS/ 45 DAT	At harvest
Line sowing dry seeds 60 kg ha^{-1} (T_1)	61.17	80.75	94.78	1305.00	3132.10	7536.80
Line sowing hydroprimed seeds 60 kg ha^{-1} (T_2)	63.13	81.12	96.45	1575.10	3536.40	7798.90
Broadcasting dry seeds 80 kg ha^{-1} (T_3)	62.80	82.78	96.54	1436.80	3193.20	7551.60
Broadcasting hydroprimed seeds 80 kg ha^{-1} (T_4)	61.90	84.42	96.67	1348.00	3868.20	8366.50
Broadcasting dry seeds 100 kg ha^{-1} (T_5)	61.10	82.96	96.83	1292.60	3593.50	7601.90
Broadcasting hydroprimed seeds 100 kg ha^{-1} (T_6)	65.40	86.35	99.38	1643.80	3743.30	7869.20
Broadcasting pre-germinated seeds 80 kg ha^{-1} (T_7)	60.50	79.77	93.95	1369.80	3461.10	7420.40
Broadcasting pre-germinated seeds 100 kg ha^{-1} (T_8)	61.63	79.83	95.74	1399.50	2975.90	6926.40
Thomba method of planting 15 cm x10 cm (T_9)	59.33	77.09	95.30	1068.80	3359.00	7599.10
Thomba method of planting 20 cm x10 cm (T_{10})	57.60	76.63	90.55	1067.20	2817.50	5716.90
SEm (±)	**57.60**	**76.63**	**90.55**	**102.50**	**178.40**	**192.30**
LSD (0.05)	**6.78**	**5.881**	**4.52**	**307.42**	**535.21**	**576.94**

to lower number of sterile spikelets in direct seeded rice (Thakuria and Choudhary, 1995). Poor performance of pre-germinated grains in delayed and erratic emergence of seedlings and subsequently poor plant performance were due to the inability of these grains to utilize germination metabolites optimally (Farooq *et al*., 2006).

The hydroprimed treatments at higher seed rates (80 and 100 kg ha^{-1}) recorded superior yields (Table 4) and this might be due to the increased plant population in these treatments which improved the competitive ability of plants against weeds. This reduced the uptake of nutrients by weeds and thus made it available to the plants. Broadcasting hydroprimed seeds at 100 kg ha^{-1} (T_6) recorded a significantly superior straw yield and this might be due to the higher seed rate which resulted in a higher plant population and an increased vegetative

Table 3: Effect of establishment techniques on yield attributes of upland rice

Treatments	No. of panicles m^{-2}	Panicle length (cm)	Panicle weight (g)	No. of filled grains $panicle^{-1}$	Sterility percentage
Line sowing dry seeds 60 kg ha^{-1} (T_1)	409.30	23.87	2.46	96.73	17.92
Line sowing hydroprimed seeds 60 kg ha^{-1} (T_2)	405.30	23.10	2.52	102.27	12.64
Broadcasting dry seeds 80 kg ha^{-1} (T_3)	372.00	23.87	2.63	102.00	11.38
Broadcasting hydroprimed seeds 80 kg ha^{-1} (T_4)	420.00	24.39	2.78	113.60	10.48
Broadcasting dry seeds 100 kg ha^{-1} (T_5)	392.00	24.02	2.54	99.47	17.38
Broadcasting hydroprimed seeds 100 kg ha^{-1} (T_6)	397.12	24.17	2.73	108.80	11.37
Broadcasting pre-germinated seeds 80 kg ha^{-1} (T_7)	364.00	21.86	2.45	97.80	17.56
Broadcasting pre-germinated seeds 100 kg ha^{-1} (T_8)	368.70	22.83	2.41	99.53	16.38
Thomba method of planting 15 cm x10 cm (T_9)	390.70	23.40	2.51	98.27	16.75
Thomba method of planting 20 cm x10 cm (T_{10})	342.70	21.30	2.36	81.67	18.88
SEm (±)	**10.13**	**0.47**	**0.06**	**3.51**	**1.04**
LSD (0.05)	**41.39**	**1.41**	**0.19**	**10.53**	**3.13**

Table 4: Influence of establishment techniques on yield and economics of upland rice

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Line sowing dry seeds 60 kg ha^{-1} (T_1)	3671.7	3865.9	33126	1.55
Line sowing hydroprimed seeds 60 kg ha^{-1} (T_2)	3889.0	3912.6	37723	1.62
Broadcasting dry seeds 80 kg ha^{-1} (T_3)	3675.7	3875.6	36164	1.65
Broadcasting hydroprimed seeds 80 kg ha^{-1} (T_4)	3900.7	3968.9	42214	1.72
Broadcasting dry seeds 100 kg ha^{-1} (T_5)	3786.0	3941.8	37976	1.66
Broadcasting hydroprimed seeds 100 kg ha^{-1} (T_6)	3871.7	4494.8	41687	1.70
Broadcasting pre-germinated seeds 80 kg ha^{-1} (T_7)	3606.3	3814.1	35017	1.61
Broadcasting pre-germinated seeds 100 kg ha^{-1} (T_8)	3392.3	3543.7	28636	1.50
Thomba method of planting 15 cm x10 cm (T_9)	3593.7	3782.4	27736	1.44
Thomba method of planting 20 cm x10 cm (T_{10})	3023.7	3273.9	14723	1.24
SEm (±)	**109.8**	**105.7**	**2684**	**0.03**
LSD (0.05)	**329.01**	**316.49**	**8036.2**	**0.131**

growth. Better expression of plant height, tillers m^{-2} and DMP also contributed to an increased straw yield.

The results were identical with the findings of Sheela and Alexander (1995) who reported that the grain yield in rice is closely associated and dependent on production of higher number of panicles m^{-2}, number of grains per panicle, panicle weight, thousand grain weight and low sterility percentage. Farooq *et al*. (2005) reported that the higher grain yield in primed seeds might be due to rapid and regulated production of metabolites leading to healthier plants.

Results of the field experiment showed that net income and B : C ratio were influenced significantly by broadcasting of hydroprimed seeds. The highest net income (42214 Rs ha^{-1}) and B : C ratio (1.72) were obtained in broadcasting hydroprimed seeds 80 kg ha^{-1} (T_4) which was due to its higher grain and straw yield. Broadcasting required lesser labour when compared to line sowing and transplanting methods of planting. Thus a significant reduction in labour charge minimized the cost of cultivation resulting in a higher B : C ratio. Lee *et al*. (2002) also reported that the total cost of rice production by direct seeding was about 21 per cent lower than machine transplanting. Thomba method of planting at wider spacing (20 × 10 cm) registered the lowest net income (14723 Rs ha^{-1}) and B : C ratio (1.24) among all the establishment techniques. This was due to the higher labour requirement of transplanting the seedlings in the main field which resulted in a higher cost of cultivation. Wide spacing adopted in transplanting reduced the plant population leading to a declined grain and straw yield. This decline in grain and straw yield adversely altered the economics, reducing its net returns.

The study disclosed a remarkable effect of hydropiming and sowing methods on growth, yield and economics of upland rice. It may be inferred from the results that broadcasting hydroprimed seeds at a seed rate of 80 kg ha^{-1} is the cost effective method that should be practiced to obtain enhanced yield in upland *kharif* rice in coconut garden.

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