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Evaluation of Performance of Seed Coating Formulation for Direct Seeded Rice (DSR) in Dry and Puddled Conditions

K RAJA[1]*, K MALARKODI[1], C VANITHA[1], S MANONMANI[1], M KATHIRAVAN[2], V VAKESWARAN[3], K NATARAJAN[4], C MENAKA[5], V VIJAYALAKSHMI[6] AND R UMARANI[1]

[1]Seed Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu - 641 003, India
[2]Agriculture College & Research Institute, Tamil Nadu Agricultural University, Thiruvannamalai, Tamil Nadu - 606 753, India
[3]Agricultural Research Station, Tamil Nadu Agricultural University, Bhavanisagar, Tamil Nadu - 638 451, India
[4]ICAR-KVK, Tamil Nadu Agricultural University, Vridhachalam, Tamil Nadu - 606 001, India
[5]National Pulses Research Centre, Tamil Nadu Agricultural University, Vamban, Tamil Nadu - 622 303, India
[6]ICAR-KVK, Tamil Nadu Agricultural University, Vamban, Tamil Nadu - 622 303, India
*kraja_sst@rediffmail.com

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ABSTRACT: Direct Seeded Rice (DSR) is an agronomic practice wherein seeds are sown directly into the field, circumventing the conventional method of transplanting. Given the critical role of early crop establishment in DSR, enhanced seed germination and seedling vigor are imperative for achieving optimal crop performance. To this end, a study was undertaken during 2023–2024 growing season to assess the impact of the TNAU seed coating formulation, *TNAU Vidhai Amirtham*, on crop growth and yield under DSR conditions. The rice seeds were treated with TNAU *Vidhai Amirtham* @ 25 ml / kg and sown under DSR dry condition as well as puddled condition. The results showed that the rice seeds treated with TNAU *Vidhai Amirtham* @ 25 ml / kg has recorded higher field emergence (95.5%), root volume (39.5 cm^3), number for productive tillers (19.0), plant height (112.4 cm), panicle length (25.9 cm), number of seeds / panicle (199.10) and seed yield (4309 kg / ha) than the untreated control under direct seeded unpuddled dry condition. Correspondingly, the field emergence (95.6%), root volume (41.0 cm^3), number for productive tillers (31.5), plant height (118.7 cm), panicle length (26.7 cm), number of seeds / panicle (284.0) and seed yield (6375 kg / ha) were higher in the TNAU *Vidhai Amirtham* treated seeds under puddled condition compared to untreated control. Thus, rice seed treatment with TNAU *Vidhai Amirtham* @ 25 ml / kg can be followed for the better plant growth and yield under DSR system.

Keywords: Direct seeded rice, seed coating formulation, TNAU *Vidhai Amirtham*, dry sowing, puddled sowing, crop growth, Yield

Rice (*Oryza sativa* L.) is an important staple food crop in many parts of the world. It contains mainly carbohydrate in the form of starch and protein, with virtually no fat or sugar. In addition, it also contains various minerals such as zinc and phosphorus and vitamins like thiamin and niacin. It is estimated that 165 million hectares of area were cultivated with rice in worldwide. In which, India is a leading producer globally next to China with an area of about 48 million hectares with over 135 million tons of milled rice [1]. Generally, rice consumes 34 to 43% global irrigation water and needs about 800 to 5,000 liters of water per kg of rice [2]. Further, it is estimated that 65% of the available irrigation water are utilized for the rice cultivation [3]. Usually, rice is cultivated in puddled condition by transplanting the 20-25 days old seedlings. Thus, the water requirement under this method of cultivation is high which declines ground water table and increases water scarcity. Also, it has some deleterious effects on the soil environment, because of emission of methane gas. In addition, this method of cultivation requires more energy and expenditure which makes the rice production as less economical.

Alternatively, direct seeding is gaining popularity because of low water and energy requirement. In which, the direct seeded rice (DSR) requires less water comparatively with transplanting method. Labour saving (12-35%), reduction in methane gas emission (10-90%), less drudgery and less production cost are some of the advantages in DSR system of cultivation [4]. In DSR, the seeds are sown directly in the field as opposed to transplanting of

seedlings from the nursery. Therefore, production of vigourous seedlings are essential to sustain the low water availability through the DSR cultivation.

Seed coating technology has developed rapidly and provides an economical approach for seed quality enhancement. It allows the application of combinations of nutrients, fungicides, insecticides, herbicides and beneficial microorganisms to seeds. In which, it offers immense potential to supply essential nutrients to the germinating seeds and subsequently for developing seedlings and thereby increasing the seedling vigour and plant establishment. Rice seeds treated with polymer, thiram and micorrhiza was found to increase seedling vigour [5]. The better field emergence, plant growth traits and yield in rice were noticed from seeds coated with CaO_2 and *Bacillus* sp. [6]. Polymer coating reduces the infection compared to uncoated seeds and also enhances field emergence [7,8]. Polymer materials are slightly more viscous than most chemicals used as pesticides in seed treatment. Owing to exploit the polymer film coating technology to improve the seed germination and seedling vigour potential of the seeds, it is quit essential to identify the potential nutrient sources. Generally, popular nutrient sources added with polymers are hormones and growth regulators. Hormones are organic chemicals that promote the growth and development of plants at low concentration. Hence, development of hormone based seed coating formulation for enhancing seed germination and seedling vigour is vital. One such technology is 'TNAU seed coating formulation (TNAU *Vidhai Amirtham*)' has registered higher speed of emergence and germination percentage, dense roots and vigourous plants. Therefore, in order to assess the effect of the TNAU seed coating formulation (TNAU *Vidhai Amirtham*) on seedling establishment and yield performance of rice under DSR system, an experiment was conducted at different conditions.

MATERIALS AND METHODS

Study on the effect of TNAU seed coating formulation (TNAU *Vidhai Amirtham*) was conducted at Seed Centre, Tamil Nadu Agricultural University, Coimbatore during *Rabi* 2023-24. The TNAU seed coating formulation was prepared at Seed Centre, TNAU, Coimbatore and supplied to six different centres of TNAU *viz*., Department of Rice, Coimbatore; National Pulses Research Centre (NPRC), Vamban; Krishi Vigyan Kendra (KVK), Vamban; Krishi Vigyan Kendra (KVK), Vridhachalam; Agricultural College and Research Institute (AC&RI), Vazhavachanur; and Agricultural Research Station (ARS), Bhavanisagar for conducting the field experiments in the University Farm or farmers field.

The seeds were treated with the seed coating formulation in all the centres as per the treatment details: T_1 - Untreated control and T_2 - Seed treatment with TNAU seed coating formulation (TNAU *Vidhai Amirtham*) @ 25 ml / kg. Rice varieties *viz*., ADT 37, ADT 51, ADT 54, CO 53, CO 54 and CO 55 were used for conducting the experiment at different locations based on the adoptability of the varieties. The seeds were sown in the field under dry or puddled condition. The recommended package of practices was followed for both dry and puddled sown crops. The field emergence, plant growth and yield parameters were recorded in all the centres and pooled analysis was done and tabulated. Table 1 indicates the centre with varieties and method of cultivation practice followed for the experiment.

The data collected were subjected to statistical analysis and the critical difference values were calculated at 5 per cent probability level.

RESULTS AND DISCUSSION

The results of the experiment conducted at different centres showed difference between the untreated control

Table 1. Experimental centres with varieties grown and method of cultivation

S. No.	Name of the Centre	Location of the experiment	Varieties	Method of cultivation
1.	Department of Rice, TNAU, Coimbatore	Coimbatore	CO 53	Puddled condition, sowing by drum seeder
2.	NPRC, Vamban	Kambar Kovil, Pudukottai Dt.	ADT 54	Unpuddled condition, dry sowing by drum seeder
3.	KVK, Vamban	Kambar Kovil, Pudukottai Dt.	ADT 54	Unpuddled condition, dry sowing by drum seeder
4.	KVK, Vridhachalam	Manalmedu, Thirumalai Agaram and Murugankudi, Cuddalore Dt.	ADT 51 & ADT 54	Unpuddled condition, dry sowing by drum seeder & puddled condition, sowing by drum seeder
5.	AC&RI, Vazhavachanur	Nedungavadi, Thiruvannamalai Dt.	ADT 37	Puddled condition, sowing by drum seeder
6.	ARS, Bhavanisagar	Bhavanisagar	CO 54 & CO 55	Puddled condition, sowing by drum seeder

and TNAU *Vithai Amirtham* treated seeds. In case of NPRC, Vamban, the result revealed that the rice variety ADT 54 seeds treated with TNAU *Vithai Amirtham* recorded increased field emergence (95.0%), root volume (45.0 cm^3), plant height (112.4 cm), panicle length (25.9 cm) and 1000 seed weight (14.48 g) than control. Further, 12.57 percent higher yield was recorded in the TNAU *Vithai Amirtham* @ 25 ml / kg treated seed when compared to control (Table 2). Similarly, the field experiment carried out by KVK, Vamban showed that the rice seeds coated with TNAU *Vithai Amirtham* performed better in terms all biometric and yield parameters. In which, the percent increase in field emergence, root volume, plant height, and seed yield over control was 5, 60, 11 and 13 percent respectively (Table 3).

Field trial conducted by KVK, Vridhachalam in variety ADT 51 under direct seeded dry situation revealed the increased root length (30.5 cm), total number of tillers (19.0), number of panicles (205), 1000 seed weight (14.9 g) and yield (5575 kg/ha) than the untreated control (Table 4). Pest and disease incidence were also lesser in the seed coating formulation treated seeds. Likewise, the seeds sown in puddled condition have registered higher root length (41.0 cm), total number of tillers (31.5), number of seeds / panicle (284) and seed yield (6375 kg/ha) rather control. In which, the seeds sown in puddled condition had higher plant growth and yield traits than the dry condition irrespective of treatment. In the variety ADT 51, similar kind of improved plant growth and yield were recorded. Thus, the seeds treated with *Vithai Amirtham* recorded 18.8 percent higher yield when compared to control both under direct seeded and puddled conditions (Table 4).

The field trial conducted in the Department of Rice, Coimbatore during Rabi, 2023 revealed that seed treatment with TNAU *Vidhai Amirtham* @ 25 ml / kg recorded higher field emergence (96.0%), number of productive tillers (11), plant height (122.5 cm) and 1000 seed weight (24.1 g) compared to control (88.0%, 11, 122.5 cm, 24.1 g) (Table 5). Seed yield (4562 kg / ha) recorded was more in seed treatment with TNAU *Vidhai Amirtham* @ 25 ml / kg when compared to control (4153 kg / ha).

The results in the field experiment conducted by AC&RI, Vazhavachanur in rice variety ADT 37 indicates the seeds treated with TNAU *Vithai Amirtham* @ 25 ml / kg has recorded the maximum field emergence (92%), plant population (31.2 No. / m^2) and plant height (105 cm) when

Table 2. Effect of seed coating formulation (TNAU *Vidhai Amirtham*) on seedling vigour, growth and yield in direct seeded rice variety ADT 54 at NPRC, Vamban

Treatment details	Field emergence (%)	Root volume (cm^3)	Days to first flowering	Days to 50% flowering	Total No. of tillers	No. of productive tillers	Plant height at vegetative stage(cm)	Plant height at maturity stage(cm)	Panicle length (cm)	No. of seeds / panicle	1000 seed weight (g)	Seed yield / plot (25 m^2)(kg)	Seed yield (kg/ha)
T_1 - Control	90.0	27.5	105	111	6.3	5.0	88.5	106.1	24.4	188.0	13.81	9.4	3340
T_2 - Seed treatment with *Vithai Amirtham*	95.0	45.0	103	108	7.0	5.9	95.2	112.4	25.9	193.2	14.48	10.2	3760
SEd	0.29	0.21	0.91	0.48	4.60	0.05	0.28	0.41	0.24	0.36	0.05	0.10	14.37
CD (P=0.05)	0.64	0.47	1.99	1.04	NS	0.11	0.60	0.90	0.52	0.79	0.11	0.22	31.30

Table 3. Effect of seed coating formulation (TNAU *Vidhai Amirtham*) on seedling vigour, growth and yield in direct seeded rice variety ADT 54 at KVK, Vamban

Treatment details	Field emergence (%)	Root volume (cm^3)	Days to first flowering	Days to 50% flowering	Total No. of tillers	No. of productive tillers	Plant height at vegetative stage (cm)	Seed yield (kg/ha)
T_1 - Control	91.0	26.8	105	110	5.5	4.0	84.0	2763
T_2 - Seed treatment with *Vithai Amirtham*	96.0	43.0	103	108	6.2	6.0	94.0	3591
SEd	0.23	0.27	0.50	0.40	0.06	0.06	0.40	14.75
CD P=0.05)	0.52	0.60	1.03	0.83	0.14	0.14	0.84	32.14

Table 4. Effect of seed coating formulation (TNAU *Vidhai Amirtham*) on seedling vigour, growth and yield in direct seeded rice variety ADT 54 and ADT 51 at KVK, Vridhachalam

Treatment details	Root length (cm)	Days to 50% flowering	Total No. of tillers	Pest and disease incidence (%)	No. of seeds / panicle	1000 seed weight (g)	Seed yield (kg/ha)
Direct seeded dry condition (ADT 54)							
T_1 - Control	22.6	105	11.0	52	189	13.9	4625
T_2 - Seed treatment with *Vithai Amirtham*	30.5	102	19.0	25	205	14.9	5575
SEd	0.22	0.86	0.19	0.46	2.28	0.17	53.76
CD (P=0.05)	0.48	1.88	0.41	1.01	4.97	0.38	117.14
Direct seeded puddled condition (ADT 54)							
T_1 - Control	26.5	112	18.0	51	198	15.4	4950
T_2 - Seed treatment with *Vithai Amirtham*	41.0	108	31.5	25	284	15.8	6375
SEd	0.47	1.14	0.30	0.44	2.77	0.21	52.52
CD (P=0.05)	1.03	2.49	0.65	0.97	6.04	NS	114.43
Direct seeded puddled condition (ADT 51)							
T_1 - Control	30.1	122	17.0	53	208	22.9	5000
T_2 - Seed treatment with *Vithai Amirtham*	45.0	118	34.0	25	278	23.8	6000
SEd	0.34	2.02	0.35	0.41	2.77	0.25	79.25
CD (P=0.05)	0.74	NS	0.78	0.90	6.04	0.55	172.68

Table 5. Effect of seed coating formulation (TNAU *Vidhai Amirtham*) on seedling vigour, growth and yield in direct seeded rice variety CO 53 at Department of Rice, TNAU, Coimbatore

Treatment details	Field emergence (%)	Days to 50% flowering	No. of productive tillers/plant	Plant height at harvest (cm)	1000 seed weight (g)	Seed yield (kg/ha)
T_1 - Control	88.0	89	8	117.3	23.8	4153
T_2 - Seed treatment with *Vithai Amirtham*	96.0	85	11	122.5	24.1	4562
SEd	0.97	0.44	0.09	1.33	0.29	35.79
CD (P=0.05)	2.12	0.97	0.20	2.91	0.65	78.00

compared to control (86%, 27.3 No. / m^2 and 90 cm, respectively) (Table 6). More number of tillers (31.1) and productive tillers (20.6) were also observed in TNAU *Vidhai Amirtham* treatment than control (19.8 and 12.2, respectively). In addition, TNAU *Vidhai Amirtham* treatment induced early flowering (68 days) and 50 percent of flowering (76 days) whereas control took 72 days for flower initiation and 81 days for 50 percent of flowering. The maximum seed yield (4988 kg / ha) was obtained in the TNAU *Vidhai Amirtham* treated field compared to control (4055 kg / ha) (Table 6).

Rice varieties CO 54 and CO 55 sown under direct seeded puddled condition at ARS, Bhavanisagar indicated that the seeds treated with TNAU *Vithai Amirtham* @ 25 ml / kg has recorded better plant morphological and yield parameters (Table 7). In which, field emergence (95.0%), root volume (45.8 cm^3), total

Table 6. Effect of seed coating formulation (TNAU *Vidhai Amirtham*) on seedling vigour, growth and yield in direct seeded rice variety ADT 37 at AC&RI, Vazhavachanur

Treatment details	Field emergence (%)	Plant population (m^2)	Days to first flowering	Days to 50% flowering	Total No. of tillers	No. of productive tillers	Plant height at vegetative stage (cm)	Leaf length (cm)	Leaf width (cm)	Seed yield (kg/ha)
T_1 - Control	86.0	27.3	72	81	19.8	12.2	90	32.0	1.1	4055
T_2 - Seed treatment with *Vithai Amirtham*	92.0	31.2	68	76	31.1	20.6	105	37.3	1.4	4988
SEd	0.80	0.32	0.94	0.94	0.37	0.16	0.86	0.31	0.01	39.32
CD (P=0.05)	1.75	0.71	2.06	2.06	0.81	0.36	1.89	0.68	0.03	85.67

Table 7. Effect of seed coating formulation (TNAU *Vidhai Amirtham*) on seedling vigour, growth and yield in direct seeded rice variety CO 54 and CO 55 at ARS, Bhavanisagar

Treatments	Field emergence (%)	Root volume (ml)	Plant height (cm)	No. of hills/ m^2	Total No. of tillers / hill	No. of productive tillers/hill	Days to flowering	Days to 50% flowering	Days to maturity	No. of seeds / panicle	1000 seed weight (g)	Seed yield (kg/ha)
Direct seeded puddled condition (CO 54)												
T_1 - Control	90.0	39.5	66.5	22.75	28.0	24.5	71	75	104	244.7	14.45	5957
T_2 - Seed treatment with *Vithai Amirtham*	95.0	45.8	71.2	21.25	28.5	24.7	69	73	104	264.2	16.72	6424
SEd	1.12	0.34	0.71	0.25	0.31	0.29	0.99	0.96	1.36	2.35	0.16	88.41
CD (P=0.05)	0.64	0.74	1.55	0.54	NS	NS	2.17	NS	NS	5.12	0.36	192.63
Direct seeded puddled condition (CO 55)												
T_1 - Control	92.0	36.7	63.5	21.25	28.0	26.5	75	78	105	219.2	16.25	6000
T_2 - Seed treatment with *Vithai Amirtham*	98.0	54.5	70.6	25.75	29.0	26.2	72	76	105	274.5	16.42	6400
SEd	1.20	0.56	0.79	0.30	0.29	0.24	0.86	0.84	1.24	2.93	0.23	48.08
CD (P=0.05)	2.62	1.22	1.73	0.66	0.63	NS	1.88	1.84	NS	6.39	0.51	104.75

Table 8. Pooled data showed the effect of seed coating formulation (TNAU *Vidhai Amirtham*) on seedling vigour, growth and yield in direct seeded rice

Treatment details	Field emergence (%)	Root volume (cm^3)	Days to 50% flowering	No. of productive tillers	Plant height (cm)	Panicle length (cm)	No. of seeds / panicle	Seed weight 1000 (g)	Seed yield (kg/ha)
Direct seeded dry condition									
T_1 - Control	90.5	25.6	105	11.0	106.1	24.4	188.5	13.86	3576
T_2 - Seed treatment with *Vithai Amirtham*	95.5	39.5	103	19.0	112.4	25.9	199.1	14.69	4309
SEd	1.10	0.29	1.17	0.14	1.32	0.19	1.80	0.14	55.00
CD (P=0.05)	2.40	0.65	NS	0.31	2.88	0.41	3.93	0.31	119.84
Direct seeded puddled condition									
T_1 - Control	91.2	26.5	112	18.0	109.4	25.2	198.0	15.4	4950
T_2 - Seed treatment with *Vithai Amirtham*	95.6	41.0	108	31.5	118.7	26.7	284.0	15.8	6375
SEd	0.88	0.44	1.23	0.28	1.46	0.23	3.61	0.14	80.24
CD (P=0.05)	1.92	0.96	2.69	0.61	3.19	0.51	7.88	NS	174.83

number of tillers (28.5), number of productive tillers (24.7) and number of seeds / panicle (264.2) were more in the TNAU *Vithai Amirtham* treated seeds in CO 54 variety compared with control. Also, the seed yield was higher (6424 kg / ha) in the treated seed than the control (5957 kg / ha). In case of variety CO 55, similar trend of increased field emergence (98.0%), root volume (54.5 cm^3), total number of tillers (29.0), number of productive tillers (26.2), number of seeds / panicle (274.5) and yield (6400 kg / ha) were noticed in the TNAU *Vithai Amirtham* treated seeds compared to control.

Thus, the pooled data showed that the rice seeds treated with TNAU *Vidhai Amirtham* @ 25 ml / kg has recorded higher field emergence (95.5%), root volume (39.5 cm^3), number for productive tillers (19.0), plant height (112.4 cm), panicle length (25.9 cm), number of seeds / panicle (199.1) and seed yield (4309 kg / ha) than the untreated control under direct seeded unpuddled dry condition (Table 8). Correspondingly, the field emergence (95.6%), root volume (41.0 cm^3), number for productive tillers (31.5), plant height (118.7 cm), panicle length (26.7 cm), number of seeds / panicle (284.0) and seed yield (6375 kg / ha) were higher in the TNAU *Vidhai Amirtham* treatment under puddled condition than the untreated control. [9] and [5] recorded similar sort results with improved plant growth and yield when treated with polymers for quality seed production in rice. Generally, pre-sowing seed quality enhancement techniques have potential to improve field emergence of seeds, improves plant growth and development and enhances yield [10]. Seed coating technology is gaining increased relevance in sustainable agriculture particularly in reducing the use of pesticides and protect from natural environment.

The growth hormones and other chemical substances added in the seed coating formulation have the supportive beneficial effects in the improvement on emergence of seeds, seedling vigour, plant growth, pest and disease resistance and yield. [11] optimized a formulation for seed coating to control seed-borne pathogens. It has a promising antimicrobial property which could be used in the prevention of seed-borne diseases with enhanced seedling establishment. Further, seed treatment by seed coating formulation offer an increasingly accurate mode of applying other inputs in the field through which it provides a high level of defense against insects and diseases [12]. In this, combined application of insecticides and fungicides provide better storability of seeds by preventing the infestation [13].

Formulation choice is usually determined by formulation type, active ingredients, stability on storage, distribution on seed, retention on seed, other products compatibility, safety aspects, marketing choice and product competitiveness [14]. The seed coating formulation might have the mechanism of increased available oxygen for the seed during germination [15]. This results in earlier emergence and higher seedling emergence under dry direct seeded conditions. Upon moisture availability, seeds accomplished pre-germination events such as imbibition and active metabolism earlier, therefore, resulted in earlier and higher emergence [16, 17].

CONCLUSION

Seed coating formulation (TNAU *Vidhai Amirtham*) on crop growth and yield under DSR showed that the rice

seeds treated @ 25 ml / kg have recorded higher field emergence, root growth, plant height, productive tillers, number of seeds / panicle and yield.

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