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Effect of polymer seed coating with pendimethalin on germination percentage and growth characters of aerobic rice

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Abstract
Weeds are the major constraints in aerobic rice cultivation which provides stronger competition for essential growth factors. As one of the weed control techniques, we used polymer seed coating with herbicide as a seed treatment before sowing as an alternative to pre-emergence application of herbicide. The present investigation was carried to study the effect of polymer seed coating with pendimethalin on germination percentage and growth characters of rice in Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore. The experiment comprised of pot culture studies and germination test. Initially the seed were treated with polymer @ 3ml/kg of seed, this base layer provided a surface for adhesion of herbicide and added the pendimethalin with different concentrations ranging from 0.4 to 1.0 kg *a.i.*/ha. The results revealed that Polymer seed coating with pendimethalin had negative effect on emergence of paddy seeds due to its phytotoxicity and the seed coating with polymer alone does not have any effect on the emergence and development of rice.

Keywords: Weed management, polymer, seed coating, herbicide concentration, phytotoxicity, germination

Introduction
Rice (*Oryza sativa* L.) is an important food grain crop for more than 50 per cent of the world population. Its cultivated area in the world is almost 162 million hectares that produce about 756 million tonnes (www. FAOSTAT.com, 2021).

Aerobic rice cultivation is a method of growing rice in well-drained, non-puddled and non-saturated soils using specifically developed varieties. It is the process of growing a crop from dry seeds put in the ground rather than transplanting seedlings from a nursery. As a result, aerobic rice technology has been proposed to cut water usage, reduce labour demand and ameliorate climate change. Aerobic rice can save water to the tune of 45 to 55 per cent in summer season and even higher in *kharif* season as compared to continuous submerged crop (Gandhi *et al.* 2012) [7]. According to Castaneda *et al.*, (2002) [2], compared to lowland rice, water requirements in aerobic rice were 50 per cent lower (470 mm—650 mm) and witnessed an increment of 64 – 88 per cent in water productivity and a reduction in labour use by 55 per cent. Aerobic rice can save about 50% of irrigation water in comparison to lowland rice. To overcome increasing water scarcity problem, this is better choice for both present and future (Susmita Dey *et al.* 2018) [6]. When compared to weed-free plots, the dry weight of weeds increases when the nitrogen fertilizer application rate is increased from 150 to 200 kg ha^{-1}. Crops and weeds absorb nutrients in an inversely proportionate manner (Srinivasan *et al.*, 2008) [13].

The problem of weed infestation is a fundamental barrier to achieve larger yields in aerobic soil conditions because of the exposed land area during the early stages of crop growth, weeds competition for moisture, nutrients, light, space, and other resources with crop plants. Because weeds develop simultaneously with the rice crop, crop weed competition was considered in aerobic rice when compared to transplanted rice. The yield of aerobic rice will reduce to a greater extent if left un-weeded. The extent of loss in yields due to improper weed management ranges between 62.2 to 91.7 per cent (Sunil, 2018) [14]. According to Jagadish *et al.*, (2016) [9], weeds cause production drop of more than 80% in aerobic rice.

Seed Coating Polymers are used in the film coating process. The film coating process consists of the application of a thin water permeable polymer-based coating layer onto the seed, seed coating or pellet. David chikoye *et al*., (2011) stated that seed coating IR maize hybrids with imazapyr was effective for striga control.

Bluebunch wheatgrass seeds coated with herbicide protection material were moderately protected from imazapyr herbicide application. Vigor of seedlings grown from bare seed was decreased by herbicide application, as evidenced by decreased emergence, seedling height, and biomass in comparison with coated seed. (Holfus *et al*., 2021) [8].

The current study was carried out to study the effect of polymer seed coating with pendimethalin on germination percentage and growth characteristics of aerobic rice with the purpose of effectively controlling weeds.

Materials and Methods

The lab experiment was conducted in Department of Agronomy, Tamil Nādu Agricultural University, Coimbatore, Tamil Nādu to study the effect of polymer seed coating with pendimethalin on germination percentage and growth characters of aerobic rice. In the present study, a high yielding short duration drought tolerant rice variety CO 53 was used. As there is no standard protocol for seed coating of paddy with herbicide, we need to standardize the dose of herbicide with different concentrations of pendimethalin to check the germination percentage and to study its impact on growth characters of aerobic rice. Seed film coating is a method, z in which seeds are covered with polymers that increase the adherence of chemicals, thereby reducing risks of environmental contamination, formation of dust, attacks by fungi and moisture absorption during storage (Vijaya Mahantesh *et al*., 2017) [16]. The coating process consists of the application of a thin water permeable polymer-based coating layer onto the paddy seed. The liquid polymer was used for seed coating. It acts as an excellent binding material to hold the chemical. Initially the seed were treated with polymer @ 3ml/kg of seed, this base layer provided a surface for adhesion of herbicide and added the pendimethalin with different concentrations ranging from 0.4 to 1.0 kg *a.i.*/ha. All the seeds are uniformly coated, later the treated seeds were spread on a sheet under shade and dried completely. The dried seeds were used for sowing. Adsorbed pendimethalin remain on the outer surface of the seed coat and may be absorbed later by the seedling as they emerge through the seed coat following germination. Absorbed herbicides, meanwhile, enter the seed by mass flow (dispersed in imbibed water) or diffusion. Seeds continue to absorb herbicides even after maximum water imbibition. To study its impact on germination and growth characters, it was performed through germination test and pot culture.

In germination test, there are seven treatments including control with three replications *viz.*, Polymer seed coating with pendimethalin @0.5 *a.i.*/ha(T_1), Polymer seed coating with pendimethalin @0.6 *a.i.*/ha ($T_{2)}$, Polymer seed coating with pendimethalin @0.7*a.i.*/ha (T_3), Polymer seed coating with pendimethalin @0.8 *a.i.*/ha (T_4), Polymer seed coating with pendimethalin @0.9 *a.i.*/ha (T_5), Polymer seed coating with pendimethalin @1.0 a.i./ha (T_6), Control (T_7). Among the treated seeds 25 seeds are used from each treatment and kept it for germination in germination towel and maintained for 14 days in the germination chamber with watering at three days interval.

The pot culture experiment was conducted in completely randomized design (CRD) with three replications with four treatments including control. Polymer seed coating with pendimethalin at 0.4 *a.i.*/ha (T_1), Seed coating with polymer alone (T_2), Seed coating with herbicide alone @ 0.4 *a.i.*/ha (T_3) and control (T_4). Ten plants were selected randomly and tagged in each treatment for recording plant growth parameters *viz*. germination percentage, root length, shoot length, and seedling length.

Results and discussion

The germination test results revealed that, with the exception of the control treatment, no germination was observed in the polymer coated seeds with pendimethalin. 'This is due to phytotoxicity of coated seeds' in all the treatments except control. Similarly, Brzezinski *et al*., (2015) [1] reported that the seeds treated with the insecticides had a lower percentage of normal seedlings than the seeds treated with the other products, which confirms that some insecticide molecules can show toxicity in physiological analyses. In the same way Smeda and Vaughn, (1997) [12] reported that pendimethalin acts on fragmoplast causing formation of multinuclear and also on cortical microtubules causing isodiametric growth of cells and disturbance in secondary cell wall. These lead to the formation of swelling on root tips and at the base of stem, this may lead the inhibition of seed germination and increasing seedling mortality percentages**.** In order to determine whether this phytotoxicity is caused by a polymer or a herbicide, we performed a pot culture experiment.

The results of pot culture experiment was observed with the parameters of germination percentage, root length (cm), shoot length (cm)and seedling length(cm) and the data were presented in Table 1 and 2. According to the results there was significant difference between the control and treated seeds.

The germination percentage of paddy (CO 53) ranged from 85 to 90 percent. Data regarding germination percentage was presented in Table.1, Fig.1. Maximum germination percentage (87%) was recorded with Control (T_4) which was on par with Seed coating with polymer alone (T_2) (86%). No germination percentage was observed by Polymer seed coating with pendimethalin@ 0.4 *a.i./*ha (T_1) and Seed coating with herbicide alone (T_3). In the same way Lee *et al*., (1998) [10] reported that in the leafy vegetables, pendimethalin damage occurs typically through germination inhibition, growth retardation, malformation. According to Rocha *et al*., (2020) [11] treatments of soybean seeds with insecticide molecules affect the germination and evaluation of the seedlings, and have greater phytotoxicity than fungicide molecules.

Effect of treatment on morphological characters

Data regarding root length (cm) was presented in Table.2, Fig.2. Maximum root length (19) was observed with Control (T_4) par results with Seed coating with polymer alone (T_2) (18). No root length was observed by Polymer seed coating with pendimethalin@ 0.4 *a.i.*/ha (T_1) and Seed coating with herbicide alone (T_3). Dan *et al*., (2010) [5] also observed a negative effect on root growth of soybean seedlings when seeds were treated with different insecticides, especially when the treated seeds were stored (240 days). Data regarding shoot length(cm) was presented in Table.2, Fig.3. The maximum shoot length of paddy (14) was observed with Control (T_4) par results with Seed coating with polymer alone (T_2) (13). No shoot length was recorded by Polymer seed coating with pendimethalin@ 0.4 *a.i.*/ha (T_1) and Seed coating with herbicide alone (T_3). Dan *et al*., (2010) [5] reported that several products are often used on the same seed, such as the combination of fungicides, insecticides, nematicides, micronutrients, bio stimulants, polymers, dyes or pigments, powder driers and inoculants (*Brady rhizobium*). Some products may cause phytotoxicity to seeds and seedlings, and this phytotoxic effect of some molecules tends to be enhanced by increasing storage time.

Data regarding seedling length (cm) was presented in Table 2, Fig.4. Maximum shoot length (33) was observed with Control (T_4) par results with Seed coating with polymer alone (T_2) (31). No seedling length was recorded by Polymer seed coating with pendimethalin@ 0.4 *a.i.*/ha (T_1) and Seed coating with herbicide alone (T_3). Taylor *et al*., (2012) [15] reported that specific seed-treatment compounds may be phytotoxic and the ability of a particular compound to diffuse through the seed coat is related to the chemical nature of the seed-covering tissues and the physico-chemical properties of the compound applied.

Table 1: Effect of treatment on seed germination

Treatment	Germination percentage
T1-Polymer seed coating with pendimethalin @0.4 a.i./ha	0.00
T2-Seed coating with polymer alone	85.67
T3-Seed coating with herbicide alone	0.00
T4-Control	86.33
Mean	43.00
S. Em. ±	0.55
C.D (P=0.05)	1.80

Table 2: Effect of treatment on morphological characters

Treatments	Root length	Shoot length	Seedling length
T1-Polymer seed coating with pendimethalin @0.4 a.i./ha	0.00	0.00	0.00
T2-Seed coating with polymer alone	18.00	13.00	31.00
T3-Seed coating with herbicide alone	0.00	0.00	0.00
T4-Control	19.00	14	33.00
Mean	9.25	6.75	16.00
S. Em. ±	0.18	0.13	0.20
C.D (P=0.05)	0.59	0.43	0.68

Control treatment Polymer coated seed with pendimethalin treatment

Control treatment Polymer coated seeds treatment Polymer seed coating with herbicide treatment

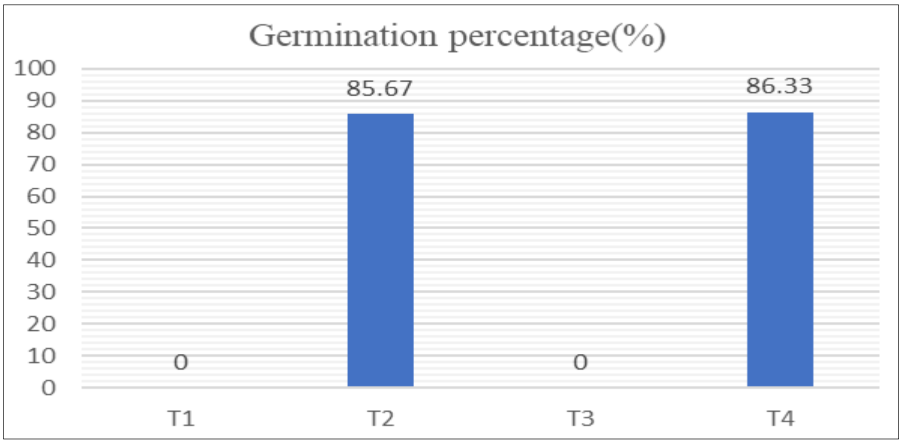

Fig 1: Histogram presenting percentage of germination due to the effect of treatments

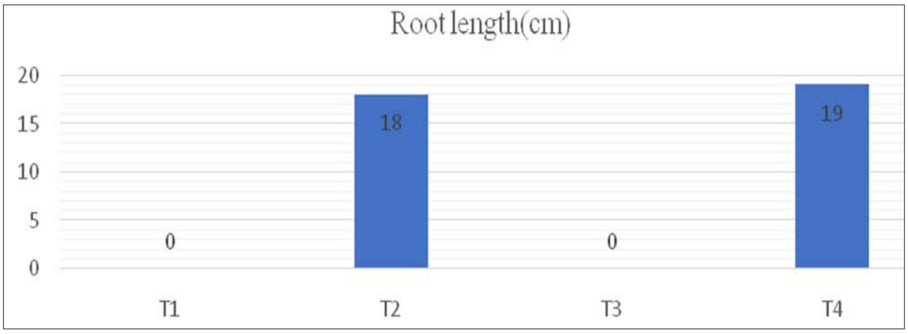

Fig 2: Histogram representing root length due to the effect of treatments

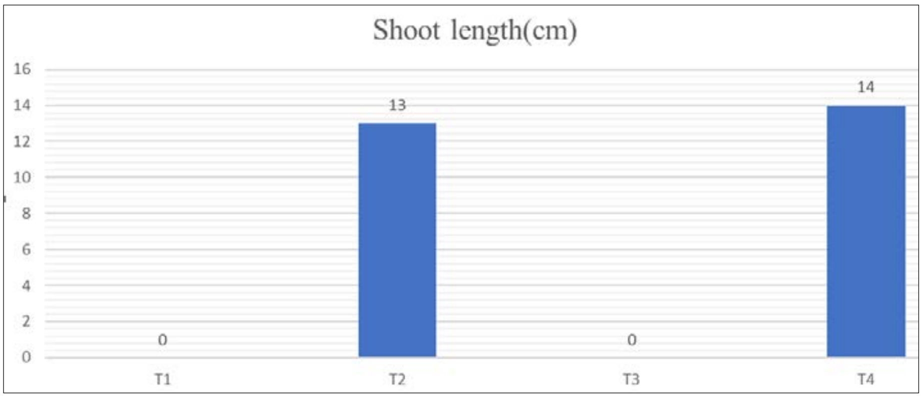

Fig 3: Histogram representing shoot length dueto the effect of treatments

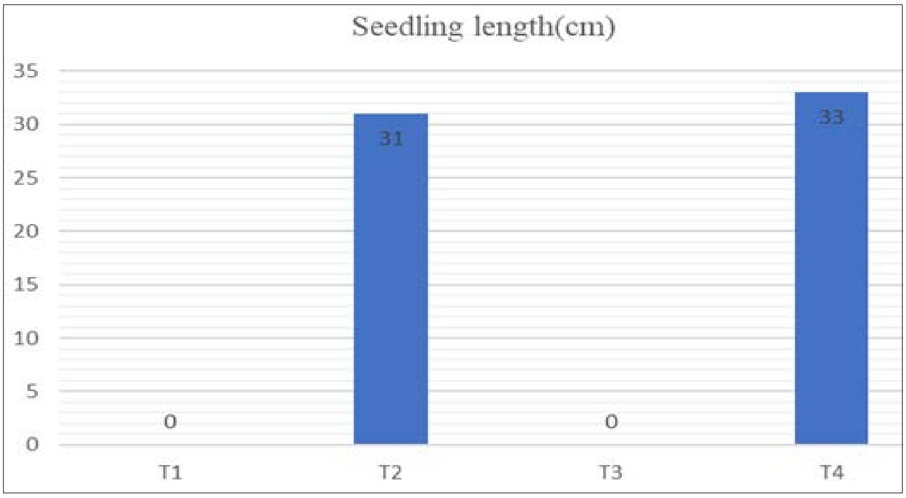

Fig 4: Histogram representing seedling length due to the effect of treatments

Conclusion

Results of germination tests showed that polymer seed coating with pendimethalin had a negative impact on the emergence of paddy. This is due to phytotoxicity of coated seeds.pot cultures studies revealed that seed coating with polymer alone had no effect on the emergence of paddy (CO 53) seeds, whereas seed coating with pendimethalin had a negative impact on the emergence of paddy seeds and it made clear that the herbicide effect was the cause of the coated seed's phytotoxicity.

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