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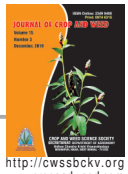

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Emergence and growth of weedy rice species in response to soil burial depth, moisture and period of sowing

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ABSTRACT

An experiment was executed to reveal the emergence and growth of different species of weedy rice under different soil burial depth, moisture condition and sowing time during the year of 2017- 2018 as a pot culture experiment. Seeds of the species were sown in seven soil depths i.e., 0, 2.5, 5, 7.5, 10, 12.5 and 15 cm. Two water regimes (saturated and unsaturated) were maintained for the experiment. The seeds were sown in consecutive eight months starting from July, 2017 to February, 2018. The experimental findings revealed that the highest germination and emergence percentage was recorded in the month of August. The lowest germination percentage was recorded in the month of January. The germination and emergence of all the species were higher in 0.0 cm soil depth and it gradually decreased with increase in soil depth. Out of four species under study Oryza minuta recorded the highest germination and emergence on 15 cm burial depth. In case of O. rufipogon the highest germination percentage was exhibited in the month of September and lowest in December. O. minuta showed the lowest germination percentage in the month of January and showed highest germination percentage in the month of August. O. barthii registered the highest germination percentage on the month of August. The emergence capability and the growth behavior of species of weedy rice were greatly controlled by burial depth of soil, soil moisture condition and month of sowing.

***Keywords*:** Germination, month of sowing, soil burial depth, soil moisture condition, weedy rice species.

Weedy rice which is the cross product of wild and cultivated rice and again with intermediate and cultivated rice, is a significant problematic weed in rice growing areas throughout the world and an emerging threat in many Asian regions. Different spices of weedy rice has been noticed as troublesome weeds in the present situation which seriously has a negative impact on rice production. Day by day weedy rice is become spreading in many rice growing areas of Asia, including India, Malaysia, Sri Lanka, Philippines, Thailand, Vietnam, and South Korea. The weedy rice infestation is found in Tamil Nadu, Madhya Pradesh, Andhra Pradesh, Orissa, West Bengal, Bihar, Karnataka, Kerala, Assam, Uttar Pradesh, and many other parts of India (Abraham and Jose, 2015 and Anjali *et al*., 2018). The flowers of weedy rice species blossom earlier than the cultivated paddy varieties and produce much more seeds that easily shatter. Changeable dormancy and early bursting habits of these species are the important features for promoting its invasion (Chauhan, 2013). At the early stage of life as weedy rice has the same morphological characters with cultivated rice, hand weeding becomes very much problematic to control. Moreover, it is very much difficult to control the weedy rice species within the field of the cultivated varieties because of their genetic and biochemical similarity. Unlike cultivated varieties, weedy rice seeds show variable degree of dormancy and tendency for the seeds to shatter as soon as they are matured (Perreto *et al*., 1993). Seeds mature within a short period and shatter immediately facilitating the build-up of weed seed bank before the farmer gets a chance to remove the seeds and get along with the harvest of rice crop. Although many research on seed dormancy, growth behaviour, mechanisms were carried out but the emergence effect for the control of germination ability are basically unknown (Foley, 2001; Koornneef *et al*., 2002). Emergence of the weedy species is greatly affected by water availability to the plants and soil, texture of the soil and the burial depth of the seeding which in turn is exactly related to the tillage operation taken for the preparation of seedbed. Elements like irrigation interval, flooding depth, moisture condition, period of moist, stage of development of the weeds (Kent and Johnson, 2001) and the burial depth of the seeds of weed species are the crucial factors which affect the emergence and the growth behaviour of weedy rice species (De Datta, 1981). Many times water logging condition was prescribed as a significant measure to control the species of weedy rice. The burial depth plays a significance role in emergence of both rice and weed seeds (Harper and Obeid, 1967). These problematic characters of weedy rice related with the cultivated rice varieties in West Bengal may be mitigated by adopting

Short Communication

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the proper water management system and burial depth of the seeds of weeds at the early stages of crop establishment. The prospective of using water logging condition and the depth of seeding are the important factors of integrated weed management where waterlogged tolerant varieties of rice are used is time taking and needs assessment. The purpose of this experiment was to establish the effects of flooding (waterlogged condition) and the soil burial depth on the germination and growth behaviour of different weedy rice species found in the survey under red and lateritic belt of West Bengal and cultivated rice genotypes.

The experiment was conducted as pot culture during 2017-2018. Seeds of weedy rice species were collected during the survey of different villages of four district *viz.* Purulia, Bankura, Birbhum and parts of Burdwan which come under red and lateritic belt of West Bengal. The seeds were then cleaned immediately and placed in plastic jar which was hermetically sealed. Seeds collected through survey were then stored in dark and at room temperature (20º C). The earthen pots of 25 cm × 25 cm size were filled with soil collected from the field where weedy rice species were not present. Mechanical analysis of soil was done for determination of textural class. Soil organic carbon and pH were also determined. The soil was sandy loam (Sand 61.5 %; Silt 20.5; Clay 18.0 %) with pH 6.4 and organic carbon 0.42%. The soil was cleaned and ground finely and passed through 2 mm sieve mesh net. The soil was sterilized before use in the pot after placing the soil in oven under 105° C temperature for 72 hours. The earthen pots were marked using a permanent marker and a scale. This mark indicated the depth of 0.0 cm. For the higher depth treatments, other marks were used in the earthen pots, according to the fixed depth like 2.5, 5, 7.5, 10, 12.5 and 15 cm. Extra soil was added in the pots until reaching the predestined depth. The burial depths taken under consideration were 0, 2.5, 5, 7.5, 10, 12.5 and 15 cm. The soil should be uniformly pressed to avoid differential resistance to seedling emergence at the time of pot filling. For the 0.0 cm burial depth treatment, twenty seeds of each weedy rice species were distributed on the soil surface. The four different weedy rice genotypes *viz. Oryza rufipogon, O. nivara, O. barthii* and *O. minuta* were taken as treatments. For the greater depths, twenty seeds of weedy rice species were sown at the surface layer of the soil and of each depth and soil was added up to the pot's standard surface, at the first mark. watering was done daily to maintain the saturated condition (500 ml of water for 1000 g of dried soil), whereas for unsaturated condition water was given when the soil cracks were shown prominently. The trial was conducted using the split-split-split plot arrangement within a complete randomized block design (RBD) with three (3) replications. The germination and emergence were recorded at 7, 15, 20, 25 and 30 DAS. The seeds were sown in consecutive eight months starting from July, 2017 to February, 2018. The percentage data of germination was transformed by using Arc sin transformation and analyzed in Microsoft Excel (Rao, 1998).

The data on germination and emergence percentage of different species of weedy rice over different soil moisture conditions, depths of burial and months were statistically analysed after Arc Sin transformation and are presented in Table 1. It is revealed from the table that the germination percentage was significantly higher in saturated condition than unsaturated one. The germination percentage was the highest in the species *O. minuta* and the lowest in case of *O. rufipogon*. From the Table 1, it revealed that with the increase in burial depth, the germination percentage gradually decreased. The highest germination percentage was recorded from the top portion of the soil *i.e*., surface soil and gradually decreased with the increase in burial depth and the lowest from 15 cm. The highest germination percentage was recorded in the month of August which was statistically at par with September. The lowest germination percentage was recorded in the month of January which was statistically at par with the month of February. The interaction effect of burial depth (cm) and different species of weedy rice was found significant (Table 2). *O. minuta* showed maximum germination percentage under 0.0 cm burial depth. Significantly lower germination percentage was observed in 15 cm burial depth. The germination of all the species was higher in 0.0 cm soil depth and it gradually decreased with increase in soil depth. Out of four species under study *O. minuta* recorded the highest germination percentage on 15 cm burial depth followed by *O. barthii* and *O. nivara* (Fig. 1). Again, the interaction effect of different species of weedy rice and different months of a year was found significant (Table 3 and Fig. 3). In case of *O. rufipogon* the germination percentage was highest in the month of September and the lowest in December. *O.minuta* showed the lowest germination percentage in the month of January and showed highest germination percentage in the month of August. *O. barthii* also registered the highest germination percentage in the month of August which was statistically at par with that of the month of September. The lowest germination was registered in the month of February. *O. nivara* also recorded the same trend as *O. barthii*. Analysis of the results showed that the germination percentage of all the species of weedy rice was reduced with increase of soil burial depth. It may be possible due to in dormancy differences characteristic of the weedy rice species taken for the experiment, temperature and the flooded conditions, and the different soil characteristics. Particle

Table 1: Effect of treatments on germination and emergence of different species of weedy rice

Treatments	Germination percentage
A. Soil moisture condition (2)	
Unsaturated	43.04 (46.58)
Saturated	47.83 (54.93)
SEm (±)	**0.16**
CD (at 0.05)	**0.97**
CV (%)	**7.42**
B. Species (4)	
O. Minuta	56.95 (70.26)
O. Barthii	52.91 (63.64)
O. nivara	41.83 (44.48)
O. rufipogon	30.03 (25.05)
SEm (±)	**0.21**
LSD (0.05)	**0.63**
CV (%)	**8.31**
C. Burial depth (7)	
0 cm	51.57 (61.37)
2.5 cm	50.71 (59.90)
5 cm	46.75 (53.06)
7.5 cm	43.74 (47.80)
10 cm	43.73 (47.78)
12.5 cm	43.31 (47.05)
15 cm	38.21 (38.26)
SEm (±)	**0.25**
LSD (0.05)	**0.71**
CV (%)	**7.73**
D. Month (8)	
July	44.66 (49.41)
August	50.33 (59.24)
September	49.71 (58.19)
October	49.34 (57.55)
November	47.56 (54.46)
December	41.15 (43.30)
January	40.32 (41.87)
February	40.39 (41.99)
SEm (±)	**0.26**
LSD (0.05)	**0.72**
CV (%)	**7.42**

(Note: Figures in the parentheses are original value in percentage and the data were subjected to arc sin transformation)

size of the soil has been shown to affect the soil physical characteristics, which can interfere with the germination and emergence (Cussans *et al.*, 1996). However, these universal differences, the emergence of weedy rice species increases proportionately with seed burial depth in soil (Benvenuti and Macchia, 1997; Vleeshouwers, 1997). It has been shown that soil compactness hinders the ability of seeds to reach the surface of the soil at pre- emergence seedling growth (Hegarty and Royale, 1978). Furthermore, the germination and dormancy were directly related with the soil compactness (Terpstra, 1995). Sun light plays an important role in greater germination on the soil surface. Absence of light with increase in the soil burial depth and soil gas diffusion could be resulted in reduced germination and the emergence of weedy rice species (Benvenuti and Macchia, 1995). Physical limitation of the seedlings, another possible reason for reduced emergence with increasing depth could be physical limitations of the seedling, *i.e*., insufficient seed reserves to enable it to reach the soil surface as reported by Bolfrey-Arku *et al*.(2011) who reported that the physical limitation of the seedlings played an important role in reducing the germination, emergence and growth behavior of seedlings with increase in the soil burial depth.

The ecological studies on germination of weedy rice species revealed that the highest germination and emergence percentage was recorded in the month of August which was statistically at par with September. The germination percentage was lowest in the month of January which was statistically at par with the month of February. The highest germination per cent was executed by all the weedy rice species under 0.0 cm burial depth and emergence per cent was the lowest in15 cm burial depth of seed. The interaction effect of burial depth (cm) and different species of weedy rice was found significant. *O. minuta* showed the highest germination percentage under 0.0 cm burial depth. Significantly lower germination percentage was observed in 15 cm burial depth. The emergence of all the species was higher from 0.0 cm soil depth and it gradually decreased with increase in soil depth. Out of four species under study *O. minuta* recorded the highest emergence percentage on 15 cm burial depth followed by *O. barthii* and *O. nivara.* In case of *O. rufipogon* the highest emergence percentage was exhibited in the month of September and the lowest in December. *O. minuta* showed the lowest germination percentage in the month of January and highest in the month of August. *O. barthii* registered the highest germination percentage on the month of August which was statistically at par with that of the month of September. The lowest germination was registered in the month of February. *O. nivara* also recorded the same trend as *O. barthii.*

Table 2: Germination of different species of weedy rice under different burial depths of seed

Species (4)	Burial depth (cm) (7)						
	0 cm	**2.5 cm**	**5 cm**	**7.5 cm**	**10 cm**	**12.5 cm**	**15 cm**
O. rufipogon	45.94 (51.64)	41.54 (43.97)	40.42 (42.03)	30.39 (25.60)	26.96 (20.56)	22.14 (14.20)	0.00 (00.00)
O. nivara	57.24 (70.73)	53.05 (63.87)	51.84 (61.82)	49.09 (57.12)	48.88 (56.76)	21.15 (13.02)	11.55 (4.01)
O. barthi	65.67 (83.03)	59.76 (74.63)	56.62 (69.72)	55.83 (68.46)	52.55 (63.02)	42.24 (45.19)	21.51 (13.44)
O. minuta	67.19 (84.98)	63.31 (79.82)	61.83 (77.71)	58.36 (72.40)	56.71 (69.87)	47.15 (53.75)	23.07 (15.35)
SEm (±)				**0.51**			
LSD (0.05)				**1.42**			
CV (%)				**7.73**			

(Note: Figures in the parenthesis are original value in percentage and the data were subjected to arc sin transformation)

Table 3: Germination of different species of weedy rice over the months

Months (8)	Species (4)			
	O. rufipogon	***O. nivara***	***O. barthi***	***O. minuta***
July	24.84 (17.65)	42.97 (46.46)	52.81 (63.46)	58.02 (71.95)
August	33.94 (31.17)	48.00 (55.22)	57.30 (70.81)	62.07 (78.06)
September	37.00 (36.22)	45.81 (51.42)	57.17 (70.61)	58.86 (73.26)
October	22.25 (14.34)	37.96 (37.83)	52.76 (63.38)	58.24 (72.30)
November	19.45 (11.09)	38.39 (38.56)	52.52 (62.98)	53.77 (65.07)
December	16.01 (7.61)	35.28 (33.36)	40.32 (41.86)	46.42 (52.48)
January	23.22 (15.55)	30.5 (25.76)	43.03 (46.57)	43.13 (46.74)
February	25.64 (18.72)	25.19 (18.11)	41.28 (43.52)	44.34 (48.88)
SEm (±)		**0.52**		
LSD (0.05)		**1.44**		
CV (%)		**7.42**		

(Note: Figures in the parentheses are original value in percentage and the data were subjected to arc sin transformation)

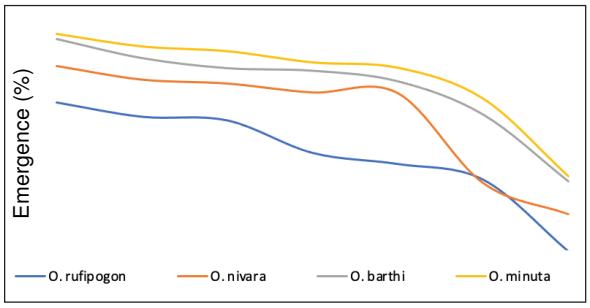

Fig. 1: Emergence of different species of weedy rice under different burial depths of seed

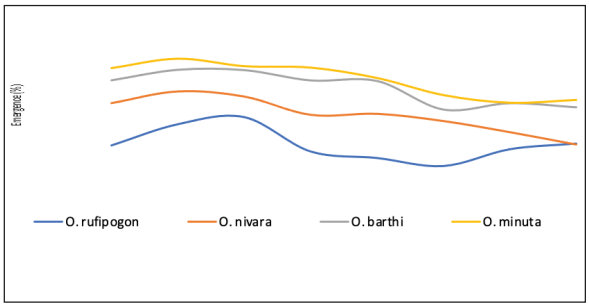

Fig. 2: Emergence of different species over the months

Plate-1(a) *Oryza rufipogon*

Plate-1(b) *Oryza nivara*

Plate-1(c) *Oryza minuta*

Plate-1(d) *Oryza barthii*

Plate-1(a-d): Four weedy rice species observed in lateritic belt of West Bengal and taken under this study.

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