www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 1116-1120

www.thepharmajournal.com
Received: 02-10-2023
Accepted: 09-11-2023

Kanhaiya Lal
Ph.D. Research Scholar, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Mukesh Kumar
Professor cum Chief Scientist, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Vikram Bharati
Associate Professor cum Chief Scientist Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Jyostnarani Pradhan
Assistant Professor cum Scientist, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

SS Prasad
Associate Professor cum Chief Scientist Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Corresponding Author:
Kanhaiya Lal
Ph.D. Research Scholar, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Exploring vertical weed seed distribution and seedling emergence patterns in rice weed species: A comparative analysis across varied test weights and crop establishment methods

Kanhaiya Lal, Mukesh Kumar, Vikram Bharati, Jyostnarani Pradhan and SS Prasad

Abstract
Managing weeds involves understanding the distribution of weed seeds and how they emerge. Many agronomic practices, such as tillage, influence these factors, thus playing a critical role in weed management strategies. A study during the rainy (*kharif*) season of 2021 to understand the impact of different crop establishment methods- W1:Puddled transplanted rice (PUTTR); W2:Direct seeded rice on permanent beds (PBDSR)(+R)-with residue; W3:ZTR -Zero till direct seeded rice-R (without residue); W4:ZTR -Zero till direct seeded rice +R (Residue); W5: UPTR-Unpuddled transplanted rice; on the vertical spatial distribution of weed seeds within the soil and the emergence dynamics of distinct weed species was systematically assessed. Based on the results, PBDSR+R and ZTR +R/-R possessed 83% and 17% beads, respectively, in the 0-3 cm and 3-6 cm. There were no beads found in the lesser disturbed soil at the lower depth. Contrary to conventional tillage (PUTTR and UPTR), which resulted in higher soil disturbance, conventional tillage (PUTTR and UPTR) produced only 11% and 21% beads on top layer (preliminary 3 cm) and 21% and 34% on 3-6 cm, 38% and 28% on 6-9 cm and 26% and 13% on 9-12 cm, respectively. A high proportion of weed seeds are buried below 3 cm under PuTTR and UPTR systems, reducing weed incidence. Furthermore, the study revealed that regardless of test weight, the maximum seedling emergence occurred in ZT without residue, followed by ZT+R. However, higher emergence occur in relatively higher test weight. Weeds germinated the least in PuTTR and UPTR. Using tillage methodologies in conjunction with complementary weed control measures, the present study provides valuable insights that can influence judicious decision-making in the field of weed management.

Keywords: Vertical distribution, weed emergence pattern, test weight, rice weeds

Introduction
In many parts of India, rice is a staple food and a key component of the diet. There was a greater preference in India for conventional puddled rice. However, conventional practices have several drawbacks. As input costs rise, farmers are under financial strain, mostly due to tillage and high labor costs. As a result of these practices, the subsequent wheat sowing process is delayed. The downside of conventional farming is that they disrupt the natural state of the soil, thereby preventing the wheat crop from growing and developing properly. It becomes difficult to cultivate wheat when soil conditions are disturbed, causing significant obstacles. In contrast, standing water inhibits the growth of weeds during crop establishment. Due to the fact that cultivated crops and weeds are not distinguished by distinct size variations, direct seeded rice (DSR) production is hindered by the presence of weeds (Hossain *et al.*, 2020; Chauhan, 2012) [12, 9]. In contrast, direct seeding with dry seed has multiple advantages, including reduction of soil erosion, improvement of soil properties, conservation of soil moisture, and reduction of fuel consumption. Indian farmers had adopted DSR systems widely. Besides increasing crop yields, DSR systems also reduce chemical fertilizer usage and increase water availability. As well as reducing greenhouse gas emissions, this technology improves air quality.
The vertical distribution of weed seeds in soil can, however, be affected by changes in tillage practices and shape and size of the weed seeds, which leads to an increase or decrease in weed species abundance. As a result, a significant number of weed seed banks are present near the soil surface in ZT systems, resulting in weed species that are light-dependent, such as

Leptochloa chinensis, *Ammannia baccifera* and *Echinochloa cru galli* (Yadav *et al*., 2018; Hossain *et al*., 2020; Padmakumari *et al*., 2019; Singh *et al*., 2016) [19, 12, 14, 18]. Alternatively, conventional tillage may favor the growth of weeds that can tolerate deeper burials. There is a possibility that this could change the composition of the weed seed bank. The extent of knowledge on weed emergence of *Leptochloa chinensis*, *Ammannia baccifera*, *Caesulia axillaris*, and *Echinochloa crusgalli* in conventional and DSR crops is limited. Reduced tillage has a significant impact on weed species, and research is essential for understanding it. Using different establishment methods, we investigated how the vertical distribution of weeds and weed emergence patterns differed according to test weight. By doing so, we can better understand the germination ecology and make better decisions about early weed management.

Materials and Methods

Field investigations were conducted in 2021 and 2022 growing seasons in ongoing (Since 2006) experiment "Long-term Research on Conservation Agriculture in a Rice-Wheat Cropping System of Eastern Indo-Gangatic plains" by CIMMYT at Research farm in Dr. Rajendra Prasad Central Agricultural University, Pusa situated in North of Bihar, India. The research evaluated different type of crop establishment method listed in table 1.

Seedling emergence pattern

The rice weeds taken for study of different test weight were 1-2 mg (*Ammannia baccifera)*, 0.1-0.5 g (*Caesulia axillaris and Leptochloa chinensis)* and 1-2 g (*Echinochloa crusgalli)*. All the weed seeds collected from mature plants from Research farm, Dr. RPCAU, Pusa. Collected seeds were stored at room temperature. Specific seed measurement of weed species given in table 2. Seeds (@100 m^{-2}) were spread evenly 3 months before initiating tillage for rice crop in 1 m x 2 m plot size, and with subsequent seedlings emerging after crop sowing were observed at 7 days interval upto 56 days. Additionally, control plots were established without introducing seeds of weeds, and seedling emergence was measured to determine the natural seed bank. Data presented in emergence rate after subtracting the control plot.

Vertical seed (plastic bead) distribution

Plastic beads (1.5 mm x 1mm) serving as proxies for weed seeds, were uniformly scattered in 2m x 2m area just before of tillage were employed to evaluate the influence of tillage on the vertical distribution of seeds within the soil. 3 passes of dry tillage with harrow, 2 passes of cultivator in ponded water followed by 1 planking done in PuTTR. In ZT, sowing done through zero till seed-cum-fertilizer drill (table 1). The crop establishment methods adopted during rice crop season in different treatments was explain in detail under t8able 1. After planting, soil sampled to count the distribution at different depth (i.e. 0-3 cm, 3-6 cm, 6-9 cm and 9-12 cm) and presented as a percentage relative to the total bead count across all depths.

Statistical analysis

A two-way ANOVA was used in order to analyze vertical seed distribution across different tillage systems based on a randomized block design, which consisted of incorporating tillage as a factor and depth as the other, using the Sigma Plot 15.0 statistical software package. Due to the presence of interaction effects between year and time (DAS), the results for each year of the study were analyzed individually in order to determine when seedling emergence was influenced by different tillage systems at each sampling time (DAS). An application of SigmaPlot 15.0 software was used to implement a functional three-parameter sigmoid model of seedling emergence for each species, under varying tillage systems. The model, which was applied to SigmaPlot 15.0 software, was expressed as follows:

$$E (\%) = E_{max} / (1 + \exp((x - T_{50}) / E_{rate}))$$

In this equation, E represents the total seedling emergence (%) at time x, E_{max} represents the highest percentage of seedling emergence ever recorded (%), T_{50} represents the time required (in days) to obtain 50% emergence, and E_{rate} represents the slope around T_{50}.

Results and Discussion

Vertical seed distribution influences by crop establishment method

Vertical distribution was not found significant under different tillage system. However, Vertical distribution of beads found significant (p<0.05) with respect to soil depth and interaction between tillage practices and depth. The tillage with lesser disturbance with PBDDR+R and ZTR+R or without residue (ZTR) had 83% of beads in 0-3 cm and 17% in 3-6 cm. None of the beads were found in the lower depth of lesser disturbed soil. In contrast, conventional tillage (PuTTR and UPTR) resulted in higher soil disturbance resulting in only 11% and 21% beads on top layer (0-3 cm) and 21% and 34% in 3-6 cm, 38% and 28% in 6-9 cm, 26% and 13% in 9-12 cm, respectively, (Figure 1).

Depending on the species, there are differences in the weed seed size, seed weight, and other morphological characteristics that influence the burial process of the weed seeds. Use of plastic beads for stimulating the weed seeds might not give the most accurate description of the seed distribution of the weed seeds. There is no doubt that stimulation can explain the system with less interference resulted in a greater portion of weed seeds near the soil surface than those that were buried. Above ground seeds more likely subjected to predation or loose viability early due to high weather fluctuation. But, conventional tillage helps to weed seed buried and continued to persist for a longer period of time or, thus becoming a part of the long-term weed seed bank.

Seedling emergence pattern

Test weight: 1-2 mg

The emergence pattern of very small seed (1-2 mg) was found significantly higher throughout study period in ZTR than transplanted system. So, Emergence was limited to less than 1% in PuTTR and UPTR whereas, 4-5% seedling recruitment in the ZTR (+R) and PBDSR (+R) and 12% emergence in 2021 (figure 2a). Three-parameter sigmoid fit model had given lesser Erate for Transplanted system than DSR approach. T_{50} in the ZTR (+R) and PBDSR (+R) were lower than other system (table 3).

Crop residue inhibits light reaching on the surface resulting lesser seed emergence even though larger number of seed remains on the surface. Crop residue inhibits light reaching the surface, which results in lesser seed emergence (Sepat *et al.*, 2017; Jat *et al.*, 2019) [15, 13], despite the presence of a larger number of seeds on the surface. This might be due to the fact that Light-induced inhibition of germination has been documented in a closely related species, *Ammannia coccinea*, as noted by Gibson *et al*., (2001) [11]. Furthermore, Shen *et al*., 2010 [16] showed more emergence at shallower depths of 3 cm and conforming to its photoblastic nature.

Test weight: 0.1-0.5 g

The results of our study showed that plots subjected to the ZTR approach displayed significantly higher levels of seedling recruitment for test weight (0.1-0.5 g) than plots subjected to the PUTTR or UPTR approach during both years of our investigation (as shown in Figure 2b). There was a maximum of 15.8% of seedling recruitment in ZTR(-R) plots, contrasting with 7-9% and 3-5% in no tillage with residue (PBDSR+R, ZTR+R) plots and transplanting plots (PUTTR or UPTR) plots (as shown in figure 2b). The increased burial depth within the more disturbed plot (PUTTR and UPTR) could contribute to a longer time period required to reach the T_{50} (17-18 days) value in comparison to the less disturbed plot (ZTR) system (detailed in Table 3).

The higher seedling recruitment observed under ZTR may be due to the fact that there were the higher seed residues on the surface (Chauhan and Johnson, 2009) [6] in combination with the stimulation caused by exposure to light and higher temperature fluctuation (Benvenuti *et al.*, 2004) [3]. On the other hand, Puddled and Unpuddled soil had lesser germination due to the higher percentage of seeds buried, higher than 0.5 cm, incapable of receiving light more than 1% (Chauhan and Johnson, 2008) [8], to a greater depth. Aulakh *et al.* (2006) [2] had also confirmed the validity of this conjecture, claiming that seeds placed deeper than 2.5 cm did not emerge to the surface. Another, *Leptochloa fusca*, a diploid closely related species (Farooq 1989) [10] had reduced germination in absence of light (Altop, *et al.*, 2015) [1]. Weed seed like *Caesulia axillaris* require 5 days for imbibition (Singh and Amritphale, 1992) [17] and also, absloute requirement of light for germination (Singh and Amritphale, 1992) [17], resulting in a 50% reduction in residue presence compared with absence of crop residue over surface.

Test weight: 1-2 g

The cumulative emergence of seed test weight i.e.,1-2g was significantly higher under zero-tillage rice (ZT) ($P<0.05$). Transplanted rice and ZRT displayed higher emergence rates around T_{50} than ZTR with residue (table 3). However, peak seedling emergence varied, with 24% of initially sown seeds emerging under ZTR, 11% emerging under crop residue (PBDSR+R/ZTR +R), and 5% to 6% emerging under transplanted rice (figure 2c). Transplanted system (Puddled and Unpuddled) had achieved T_{50} at least 5 days late than no till system.

This heightened seedling emergence experienced under ZT can likely be attributed to the comparatively smaller size seeds (outlined in Table 2). The diminutive seed size rendered them incapable of emerging from deeper burial caused by UPTR and PuTTR practices. Greater depth reduce the seedling emergence as observed in other weed specie i.e *Rumex obtusifolius*, there was no germination below 8cm (Benvenuti *et al.*, 2001a) [4]. In the ZTW(+R) and PPDSR (+R), however, there may be less emergence because there is less light which inhibit seedling emergence. Similar observations have been made in other weed species, where the emergence of seeds buried deeply is inversely correlated with their weight (Benvenuti *et al.*, 2001b) [5].

Table 1: Treatment Details

S.N.	Treatment	Tillage	Crop establishment	Residue management
W1	PUTTR	3 passes of dry tillage with harrow, 2 passes of cultivator in ponded water followed by 1 planking	Manually transplanted, random geometry	All removed
W2	PBDSR (+R)	Zero till	Direct dry seeding on permanent beds	25% wheat residue retained in rice cycle
W3	ZTR	Zero till	Direct dry seeding on flat soil, row geometry	All removed
W4	ZTR (+R)	Zero till	Direct dry seeding on flat soil, row geometry	25% wheat residues retained in rice cycle
W5	UPTR	Zero till	Direct dry seeding on flat soil, row geometry	All removed

Table 2: Weed species and their seed weight.

Scientific name	Common name	Family	Type of cotyledon	Test weight (g)
Ammannia baccifera	Monarch redstem	Lythraceae	Dicot	0.016
Caesulia axillaris	Pink node Flower	Asteraceae	Dicot	0.48
Echinochloa crusgalli	Barnyard Grass	Poaceae	Monocot	1.79
Leptochloa chinensis	Asian sprangletop	Poaceae	Monocot	0.16

Table 3: Responses of different weed test weight to seedling emergence in different crop establishment method

Test weight	Crop Establishment Method	Estimated parameters			
		E_{max}	E_{rate}	T_{50}	R^2
1-2 mg	W1-PuTTR	0.5(0.01)	0.56(0.01)	13.62(0.02)	0.99
	W2- PBDSR (+R)	5.05(0.05)	7.5(0.38)	8.41(0.49)	0.99
	W3- ZTR	12.65(0.09)	4.5(0.23)	13.98(0.21)	0.99
	W4-ZTR (+R)	4.35(0.02)	3.18(0.1)	8.53(0.11)	0.99
	W5- UPTR	0.66(0.01)	0.36(0.02)	14(0.01)	0.99
0.1-0.5 g	W1-PuTTR	2.81(0.03)	2.77(0.29)	18.67(0.23)	0.99

	W2- PBDSR (+R)	9.23(0.12)	3.79(0.39)	14.4(0.36)	0.99
	W3- ZTR	15.32(0.48)	6.67(1.06)	15.22(1.07)	0.98
	W4-ZTR (+R)	6.6(0.26)	4.68(1.25)	13.67(1.19)	0.96
	W5- UPTR	4.93(0.06)	4.33(0.38)	17.94(0.33)	0.99
1-2 g	W1-PuTTR	4.75(0.28)	6.89(1.75)	23.05(1.51)	0.97
	W2- PBDSR (+R)	11.78(0.13)	4.38(0.34)	13.88(0.32)	0.99
	W3- ZTR	24.52(0.55)	7.54(0.75)	17.01(0.75)	0.99
	W4-ZTR (+R)	10.91(0.18)	4.3(0.5)	15.53(0.45)	0.99
	W5- UPTR	6.13(0.53)	8.81(2.6)	27.06(2.02)	0.97

Standard error *(*SE) is included with parameter estimates in parenthesis. A three-parameter sigmoid model was fitted to the seeding emergence data. E_{max} is the maximum seedling emergence (%), E_{rate} denotes slope around T_{50} and T_{50} is the time *(*days*)* to reach *50%* of maximum seedling.

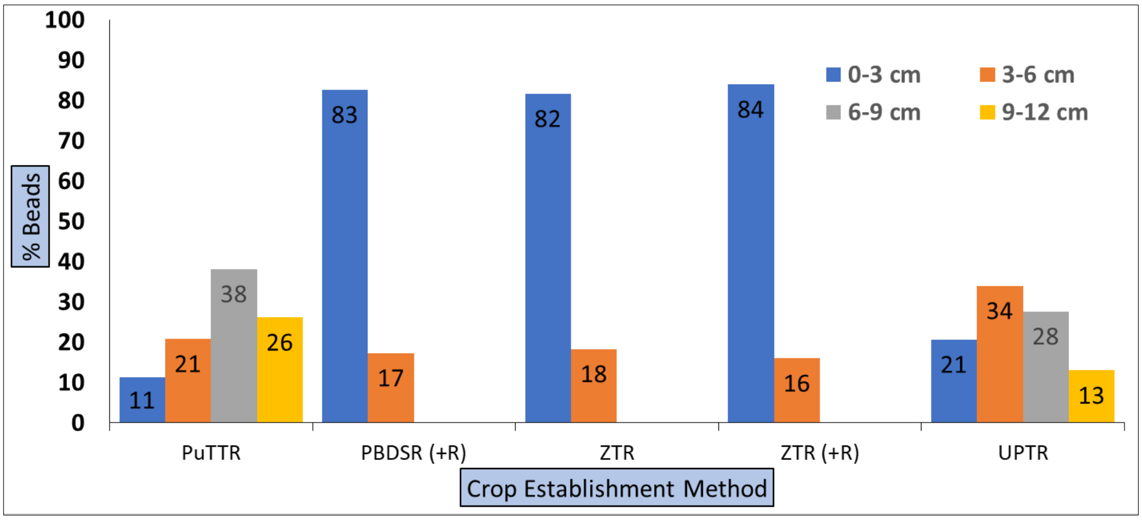

Fig 1: Vertical distribution of weed seeds as affected by crop establishment methods

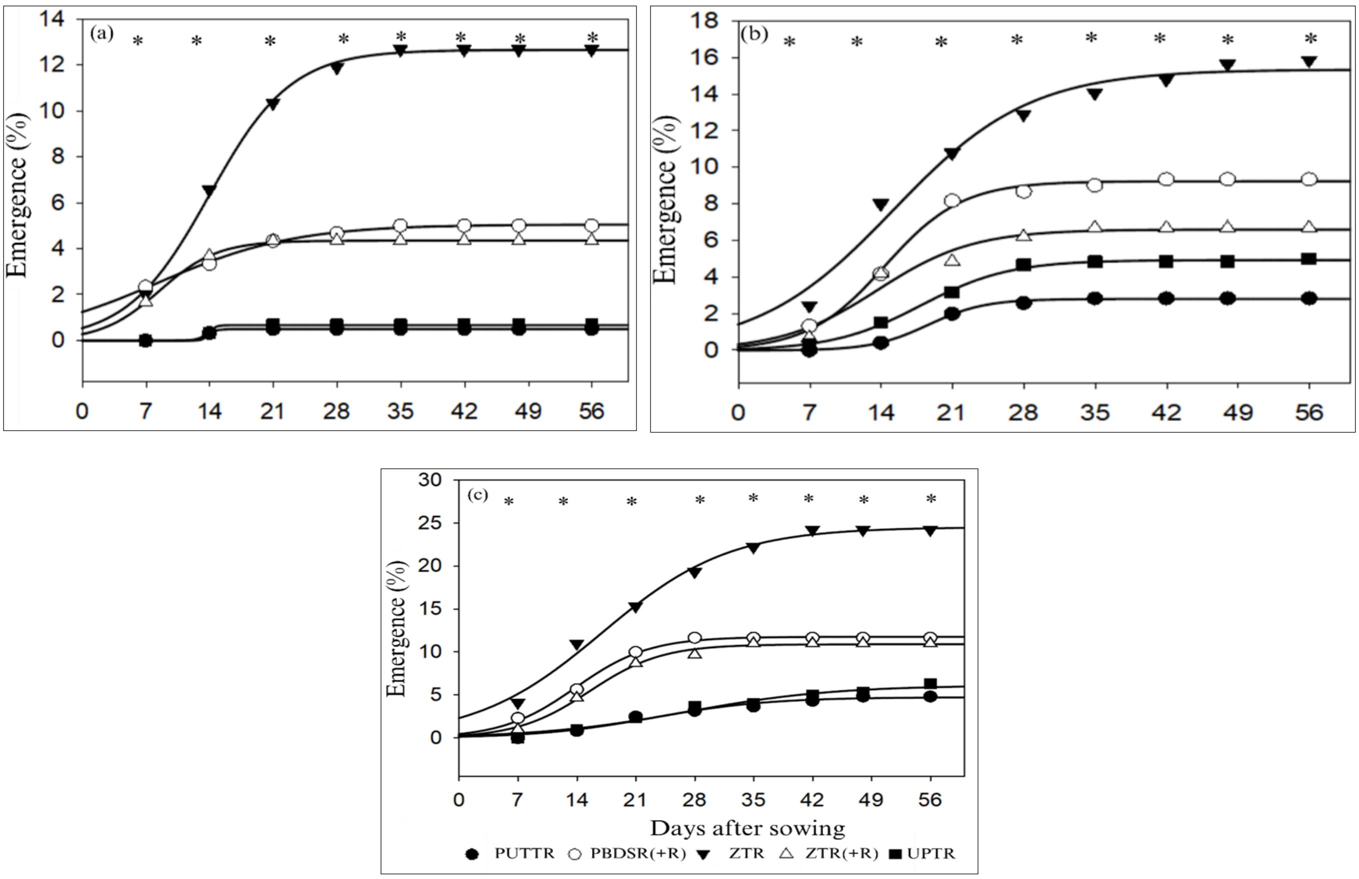

Fig 2: Seedling emergence pattern of seed test weight (a)1mg (b) 0.1- 0.5 g (c) 1-2 g in different crop establishment method; The asterisk was used to indicate significant differences among different crop establishment method was observed (p<0.05).

Conclusion

Using the results of this study, it may be possible to develop models and determine the optimal timing for weed control in crops. Regardless of the type of tillage system used or the weed species present, the maximum seedling emergence observed was 8%. Both ZT and permanent bed systems appear to promote weed growth, suggesting they may become a significant problem. It may therefore be necessary to develop management strategies for addressing this problem. Alternatively, PuTTR and UPTR methods could be used to slow the growth of weeds. Different tillage methods have different effects on seed distribution in soil and weed seedling emergence patterns. With PTTR and UPTR, weed seeds are buried more deeply whereas with PBDSR and DSR, they are kept closer to the surface of the soil. The results raise important questions about what happens to seeds that remain in the seed bank after seedling emergence is limited. Is this seed bank persistent or do these seeds decompose before the next growing season? In order to better understand the ecology of these weed species, further research is needed.

References

1. Altop EK, Mennan H, Phillippo CJ, Zandstra BH. Effect of the burial depth and environmental factors on the seasonal germination of bearded sprangletop (*Leptochloa fusca* [L.] Kunth ssp. *Fascicularis* [Lam.] N. Snow). Weed Biology and Management. 2015;15(4):147-158. https://doi.org/10.1111/wbm.12078
2. Aulakh CS, Mehra SP, Bhatia RK. Effect of temperature, submergence and seed placement depths on germination behaviour of Red Sprangletop [*Leptochloa chinensis* (L.) Nees]. Indian Journal of Weed Science. 2006;38(1&2):108-111.
3. Benvenuti S, Dinelli G, Bonetti A. Germination ecology of *Leptochloa chinensis*: a new weed in the Italian rice agro-environment. Weed Research. 2004;44(2):87-96. https://doi.org/10.1111/j.1365-3180.2003.00376.x
4. Benvenuti S, Macchia M, Miele S. Light, temperature and burial depth effects on Rumex obtusifolius seed germination and emergence. Weed Research. 2001a;41(2):177-186. https://doi.org/10.1046/j.1365-3180.2001.00230.x
5. Benvenuti S, Macchia M, Miele S. Quantitative analysis of emergence of seedlings from buried weed seeds with increasing soil depth. Weed Science. 2001b;4:528-535. https://doi.org/10.1614/0043-1745(2001)049[0528:qaoeos]2.0.co;2
6. Chauhan BS, Johnson ED. Influence of tillage systems on weed seedling emergence pattern in rainfed rice. Soil and Tillage Research. 2009;106(1):15-21. https://doi.org/10.1016/j.still.2009.10.004
7. Chauhan BS, Gill G, Preston C. Influence of tillage systems on vertical distribution, seedling recruitment and persistence of rigid ryegrass (*Lolium rigidum*) seed bank. Weed Science. 2006;54(4):669-676. Doi:10.1614/ws-05-184r.1
8. Chauhan BS, Johnson DE. Germination Ecology of Chinese Sprangletop (*Leptochloa chinensis*) in the Philippines. Weed Science. 2008;56(6):820–825. https://doi.org/10.1614/ws-08-070.1
9. Chauhan BS. Weed Ecology and Weed Management Strategies for Dry-Seeded Rice in Asia. Weed Technology. 2012;26(1):1-13. https://doi.org/10.1614/wt-d-11-00105.1
10. Farooq S. Karyological studies of kallar grass (*Leptochloa fusca* L.). CYTOLOGIA. 1989;54(2):381–384. https://doi.org/10.1508/cytologia.54.381
11. Gibson KD, Fischer AJ, Foin TC. Shading and the growth and photosynthetic responses of *Ammannia coccinnea*. Weed Research. 2001;41(1):59-67. https://doi.org/10.1046/j.1365-3180.2001.00223.x
12. Hossain K, Timsina J, Johnson DE, Gathala MK, Krupnik TJ. Multi-year weed community dynamics and rice yields as influenced by tillage, crop establishment, and weed control: Implications for rice-maize rotations in the eastern Gangetic plains. Crop Protection, 2020, 105334. https://doi.org/10.1016/j.cropro.2020.105334
13. Jat RK, Singh RG, Gupta RK, Gill G, Chauhan BS, Pooniya V. Tillage, crop establishment, residue management and herbicide applications for effective weed control in direct seeded rice of eastern Indo–Gangetic Plains of South Asia. Crop Protection, 2019, 12-20. https://doi.org/10.1016/j.cropro.2019.05.007
14. Padmakumari AP, Sreedevi B, Sivakrishna K. Effect of herbicides on feeding, survival and development of *Haltica cyanea*, a biocontrol agent of dicot weed, *Ammania baccifera* L. in rice ecosystem. Journal of Biological Control. 2019;33(2):117-121. https://doi.org/10.18311/jbc/2019/22698
15. Sepat S, Thierfelder C, Sharma AR, Pavuluri K, Kumar D, Iquebal MA, *et al*. Effects of weed control strategy on weed dynamics, soybean productivity and profitability under conservation agriculture in India. Field Crops Research, 2017, 61-70. https://doi.org/10.1016/j.fcr.2017.05.017
16. Shen X, Pyon JY, Kim DS. Germination and Seedling Emergence of *Ammannia coccinea* as influenced by environmental factors. Korean Journal of Weed Science. 2010;30(2):84-93. doi:10.5660/kjws.2010.30.2.084
17. Singh B, Amritphale D. Effect of light and its interaction with nitrate and ammoniumions in seed germination of *Caesulia axillaris*. Physiologia Plantarum. 1992;85(1):43-48. https://doi.org/10.1111/j.1399-3054.1992.tb05261.x
18. Singh VP, Singh SP, Dhyani VC, Banga A, Kumar A, Satyawali K, *et al*. Weed management in direct-seeded rice. Indian Journal of Weed Science. 2016;3:233. https://doi.org/10.5958/0974-8164.2016.00059.9
19. Yadav RI, Singh MK, Singh RK, Nagargade M. Planting methods and weed management to improve yield in dry-seeded rice. Indian Journal of Weed Science. 2018;1:22. https://doi.org/10.5958/0974-8164.2018.00005.9