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Research Article

EVALUATION OF EMERGENCE AND GROWTH RESPONSE OF *CYPERUS ROTUNDUS* AS INFLUENCED BY SOWING DEPTHS AND WATER REGIMES

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Abstract

Cyperus rotundus is rapidly growing plant can quickly form dense colonies through the extensive underground system of tuber and rhizomes. It is highly competitive for resources and causes a significant yield reduction in field crops. The nonchemical method has recently been practiced to control this noxious weed species. The current study was conducted to determine the effect of sowing depths (4, 8, 12, and 16 cm) and water regimes (deficit irrigation, medium irrigation, and frequent irrigation treatments) on *C. rotundus* shoot growth and underground growth of tubers in pots soil. Weed emergence, i.e., mean emergence time (MET), emergence index (EI), final emergence percentage (FEP), and shoot growth traits i.e. shoot density, shoot fresh weight, shoot dry weight, and tuber growth traits i.e. tuber density, tuber weight, root density, and root weight were recorded under the completely randomized (CRD) factorial design. The greatest suppression of C. rotundus emergence and growth was found at 16 cm sowing depth. The mean emergence time (MET) of *C. rotundus* was increased by increasing the sowing depth. Minimum value of shoot densty (9.5 g) and tuber density (15.75 g) were recorded at 16 cm sowing depth under deficit irrigation treatment respectively.While shoot and tuber desnity traits were also drastically suppressed by increasing sowing depth at the deficit irrigation level. It is concluded that sowing depths and deficit irrigation methods can be included as a reliable approach for controlling purple nutsedge shoot and tuber growth.

Keywords: Purple nutsedge, emergence rate, sowing depths, deficit irrigation, weed density
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1. INTRODUCTION

Cyperus rotundus, also known as purple nutsedge, showed a high degree of plasticity in morpho-anatomical characteristics, which provides this species a great potential to acquire a variety of environments (Mumtaz et al., 2019). Purple nutsedge is a C4 plants with tough perfused undergrounfd tuber and rhizomes system. It is predominantly perennial weed in many field crops (Le and Morell, 2021). This plant is considered the most damaging weed, cause damage to more than 92 countries, and is noxious in 52 crop species (Rao, 2000). It is the most abundant weed in Pakistan and is found in Indus Plains during summer seasons in important field crops such as maize, sugarcane, and cotton. It is highly competitive and causes a significant yield reduction (24%) depending on ecological and climatic conditions (Bryson et al., 2003). It is herbaceous and colonial with fiber roots that grow from 7 to 40 cm long. One of the most important characteristics of purple nutsedge is tuber production (Nasab et al., 2019). Tubers and rhizomes are the key factors in establishing this species as a weed, and both make a major set of connections in the soil (Iqbal et al., 2019). Successful management strategies can eliminate *C. rotundus* tuber production and new shoot growth viability (Peerzada, 2017). Chemical herbicide control is unsatisfactory and insufficient enough to control *C. rotundus* because chemical translocation in weed tubers is inconsistent (Baloch et al., 2021). Nonchemical approaches such as irrigation deficit and sowing depth of tuber (deep tillage) in soil have been practiced to control this noxious weed species. In this scenario, the deficit irrigation practices clutch the attention of many planners and researchers. Many scientists reported that these practices are very effective for the control of weeds in many crop plants (Silvestri et al., 2020). Le and Morell (2021) reported that water regime is criticl component of purple nutsedge. It is relaibel amangement stratigeis for the control of purple nutsedge. Irrigating the crop root zoon with appropriate moisture deficit is a key practice to monitor the weeds and conserve water. The loss of crop yield through deficit irrigation is less than the weed infestation effect. The water deficit method suppressed the weed growth and saved water (Ahmad et al., 2020). In peanut crops, 60% reduced irrigation can decrease the 25.71 dry weight of weeds (El-Metwally et al., 2020). Irrigation management is an important strategy for controlling and suppressing weed growth. Therefore, irrigation management with little stress should be promoted for good crop yield. Irrigation level influenced the weed density and biomass (Saudy et al., 2020). The population of weed species was also influenced by deficit irrigation (Halli et al., 2021; Le and Morell, 2021). The interference and yield losses from *C. rotundus* are so high that some farmers focus on abandoning their fields using a moldboard plough (deep tillage) to combat its population. Many scientists believe deep sowing of tubers by deep tillage would prevent weed emergence and observed a lower number of weed populations under deep tillage fields (Maqsood et al., 2020). Yet there is no scientific knowledge available and comparatively less work is reported on deep tillage and how this management practice affects the distribution and suppressed weed growth. Exploring weed management practices from a different perspective is necessary in modern and sustainable agriculture. Different sowing depths influence the purple nutsedge growth under different water regimes. In this context, a study was planned to evaluate the effect of different sowing depths on *C. rotundus* growth and tuber production under different water regimes.

2. MATERIALS AND METHODS

2.1. Experiment site and design

The experiment was conducted in a greenhouse at the Department of Agronomy, Ghazi University Dera Ghazi Khan, Pakistan. The experiment design was a randomized block (CRD) factorial with four replications.

2.2. Experiment detail of pot study

The experiment was conducted in plastic pots (40×40×30) having a capacity of 14 kg soil. The soil was collected from same area where purple nutsedge (*C. rotundus)* were sampled. The soil was passed through a sieve to remove the stone and unwanted material. *C. rotundus* tuber was collected in the agriculture area of the Southern Punjab region of Dera Ghazi Khan, washed, and immediately planted in experiment pots. The pots were placed in the greenhouse under ambient light with a 10 h photoperiod. Ten tubers of *C. rotundus* were sown at various sowing depths (4, 8, 12, and 16 cm) in each pot. Different water regimes i.e. deficit irrigation (water applied once at the time of sowing), medium irrigation (after the 6-day interval) and frequent irrigation (after the 3-day interval), were applied in pots. Pots were watered according to 80% water holding capacity. Only three plants of purple nutsedge were maintained after recording the emergence traits. After 60 days of sowing, data regarding the aboveground growth performance, i.e., shoot density, shoot fresh weight (g), and shoot dry weight (g), were measured in each pot. For the belowground growth traits, i.e., tuber density, tuber fresh weight (g), root density, and fresh root weight (g) traits, the soil in the pot was passed through a sieve to separate the underground organ.

2.3. Emergence related traits

According to Ellis and Robert (Ellis and Roberts, 1981), the equation MET (mean emergence time) was calculated.

$$MET = (\sum Dn) / (\sum n)$$

Where

n = Number of shoots that emerged on days

D = Number of days counted from the beginning of shoot emergence.

Final emergence% (FEP) was recorded by the given method

FEP = (Final number of shoots that emerged all day / Total number of tuber sown) ×100.

While the shoot emergence index (EI) was calculated as described by the Association of Official Seed Analysts (Analyst, 1983).

2.4. Statistical analysis

ANOVA statistically analyzed data under the CRD (complete randomized design) factorial arrangement with four replications by using the LSD test at a 5% probability level. Statistics (8.1 version) statistical software was used to find the correlation between the emergence and growth traits of *C. rotundus.*

3. RESULTS:

C. rotundus emergence and tuber growth performance were significantly affected at various sowing depths and irrigation levels. Significant variation ($P < 0.05$) was observed among the sowing depths and irrigation levels for emergence traits, i.e., mean emergence time (MET), emergence index (EI), and final emergence percentage (FEP). While the significate ($P < 0.05$) interaction among sowing depth and irrigation level were found for emergence index (EI), and final emergence percentage (FEP). Similarly, a significant ($P < 0.05$) difference was observed among the sowing depths and deficit irrigation treatments for the weed growth traits, i.e., shoot density, shoot fresh weight, shoot dry weight, tuber density, tuber weight, root density, and root weight (Table 1)

Table 1. Mean squares from analysis of variance ($P < 0.05$) for *C. rotundus* emergence traits, i.e., MET, EI, FEP and growth characteristics, i.e., shoot density, shoot fresh weight, shoot dry weight, tuber density, tuber weight, root density, and root weight at various sowing depths and deficit irrigation treatments

SOV	Sowing depths (SD)	Water regimes (WR)	SD* WR
DF	3	2	6
Mean emergence time	13.2493**	17.2749**	0.1303 ns
Emergence index	41.6060**	40.6425**	2.0366**
Final emergence %	3198.61**	8402.08**	167.36**
Shoot density	372.576 **	17.896 **	3.951 ns
Shoot fresh weight (g)	50.1485 **	0.5106 **	0.1290 ns
Shoot dry weight (g)	7.04132 **	0.16583 **	0.02528 ns
Tuber density	260.188 **	24.646 **	1.979 ns
Tuber fresh weight (g)	17.3289 **	0.8237 **	0.0083 ns
Root density	147.743 **	24.33 **	3.972 *
Root weight (g)	0.18042 **	0.06617 **	0.00538 ns
** highly significant; ns Non significant			

3.1. Weed emergence traits

Deficit irrigation and sowing depth significantly affected *C. rotundus* emerging traits, i.e., MET, EI, and FEP (Figure 1a-c). Maximum MET was observed at 16 cm sowing depth followed by 12, 8, and 4 cm depths (Figure 1a). While at deficit irrigation treatment, maximum MET was recorded compared to medium and frequent irrigation treatment (Figure 1a). The emergence index was also significantly affected at various sowing depths and deficit irrigation treatments (Figure 1b). The highest value of EI was observed at 4 cm sowing depth, and the minimum value was found at 16 cm sowing depth (Figure 1b). Similarly, the highest final emergence percentage value was observed at 4cm sowing depth (Figure 1c). FEP was also reduced by increasing the sowing depth. Deficit irrigation treatment also influenced the FEP of weeds (Figure 1c). A minimum value was found at deficit irrigation treatment (Figure 1c).

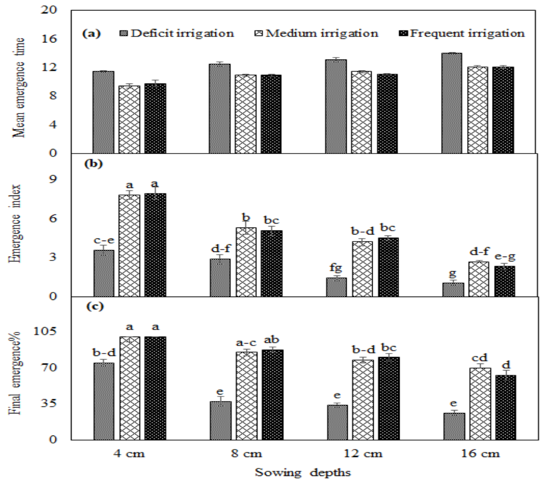

Figure.1: Effect of various sowing depths and irrigation levels on (a) mean mergence time, (b) emergence index, and (c) final emergence percentage of C. rotundus

3.2. Shoot density, shoot fresh and dry weight

The shoot density of *C. rotundus* was decreased by increasing the sowing depth. The maximum performance of shoot density was regarded at 4 cm, followed by 8 cm and 12 cm. The minimum value of shoot density was found at 16 cm (Figure 2a). Deficit irrigation also significantly affected the shoot density of *C. rotundus*. The minimum value of shoot density was found in deficit irrigation, while the shoot density was improved at frequent and medium irrigation treatments. Shoot density was severely affected by increased sowing depth through deficit irrigation (Figure 2a).

Shoot fresh weight was also affected by increasing the sowing depth. The maximum value of fresh shoot weight improved at 4 cm sowing depth, followed by 8 cm and 12 cm (Figure 2b). *C. rotundus* fresh weight was significantly reduced at deficit irrigation compared to frequent and deficit irigation treatments (Figure 2b). Similarly, the dry weight of *C. rotundus* has decreased the increasing the sowing depth. The minimum dry weight value was found at 16 cm sowing depth (Figure 2c). While irrigation treatment also improved the dry weight of *C. rotundus* (Figure 2c). The maximum dry weight value was observed in frequent irrigation treatment followed by medium irrigation treatment. Deficit irrigation badly affected the dry weight of *C. rotundus* (Figure 2c).

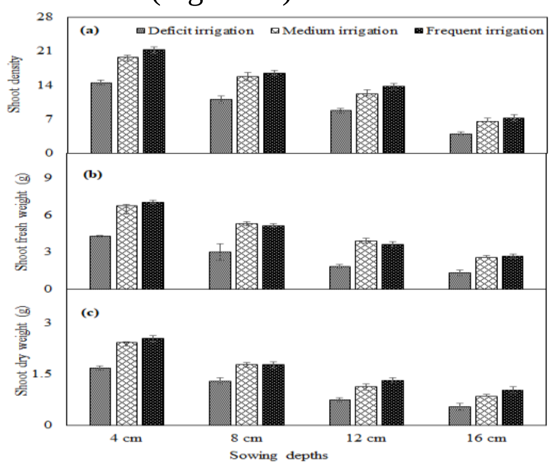

Figure. 2: Effect of various sowing depths and irrigation levels on (a) shoot density, (b) shoot dry weight, and (c) shoot dry weight of C. *rotundus*

3.3. Tuber density and tuber fresh weight

Significant effects of deficit irrigation treatment and sowing depth were observed on the tuber density of *C. rotundus*. Tuber density performance was very good at 4 cm sowing depth, while tuber density was poor by increasing the sowing depth (Figure 3a). Similarly, at frequent and medium irrigation treatments, the tuber density of *C. rotundus* was improved, and the maximum value was recorded (Figure 3a). While at defici irrigation treatment, its tuber density performance was significantly deficient (Figure 3a).

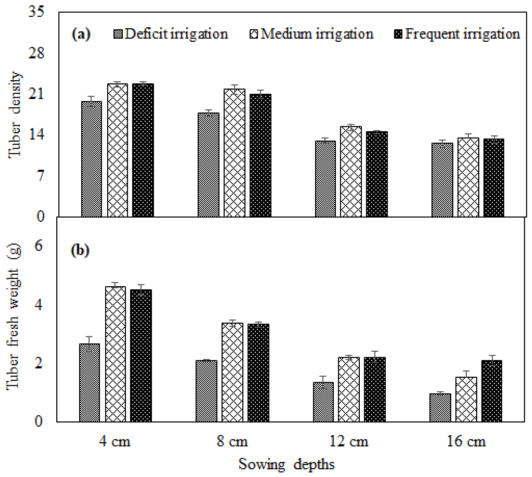

Figure.3: Effect of various sowing depths and water regimes on (a) tuber density and (b) fresh tuber weight of C. *rotundus*

Maximum growth of fresh tuber weight was found at 4 cm sowing depth followed by 8 cm, 12 cm, and 16 cm. deficit irrigation treatments also affected the tuber fresh weight of *C. rotundus* (Figure 3b). The maximum value of tuber fresh weight was found in frequent irrigation treatment followed by medium irrigation treatments (Figure 3b). In contrast, at deficit irrigation treatment, the poor performance of *C. rotundus* was observed for tuber fresh weight (Figure 3b).

3.4. Root density and root fresh weight

The root density of *C. rotundus* was decreased by increasing the sowing depth (Figure 4a). Maximum performance of root density was regarded at 4 cm, followed by 8 cm and 12 cm sowing depths. At the same time, the minimum value of root density was found at 16 cm sowing depth (Figure 4a). Deficit irrigation treatments also significantly affected the root density of *C. rotundus* (Figure 4a). The minimum value of shoot density was found in deficit irrigation, while the root density was improved at frequent and medium irrigation treatments. Root density was severally affected by increased sowing depth through deficit irrigation (Figure 4a). Root fresh weight was also influenced by increasing the sowing depth. The maximum value of fresh root weight improved at 4 cm sowing depth, followed by 8 cm and 12 cm (Figure 4b). *C. rotundus* root fresh weight was significantly reduced at deficit irrigation compared to frequent and medium irrigation treatments (Figure 4b).

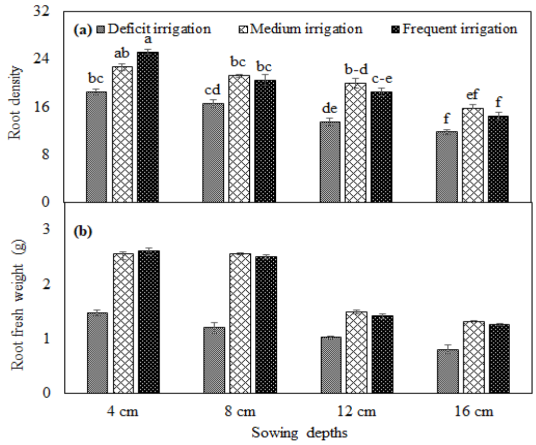

Figure.4: Effect of various sowing depths and water regimes on (a) root density and (b) fresh root weight of C. *rotundus*

3.5. Weed emergence and growth traits concerning sowing depths and water regimes

Weed emergence traits such as emergence index (EI) and final emergence percentage (FEP) had an inverse relationship with sowing depths and deficit irrigation treatments (Figure 5b, d). In contrast, mean emergence time (MET) have a direct relation with sowing depths and deficit irrigation treatments (Figure 5b, d). While weed growths traits.e., shoot density (SD), shoot fresh weight (SFW), shoot dry weight (SDW), tuber density (TD), tuber fresh weight (TFW), root density (RD) and root fresh weight (RFW) had inverse proportional with sowing depth (Figure 5c). All weed growth traits were drastically reduced by increasing the sowing depth. The maximum value of weed growth was observed at the upper surface of 4cm depth (Figure 8c). Deficit irrigation directly correlated with all weed growth traits (Figure 5a). Deficit irrigation significantly influenced the growth performance of *C.*

rotundus. Its growth was retarded at deficit irrigation treatment (Figure 5a)

3.6. Correlation among the traits

A positive correlation was observed among all emergence traits (EI, FEP) and growth traits of *C. rotundus*. Only the mean emergence trait (MET) have a negative correlation with the rest of all *C. rotundus* characteristics, i.e., EI, FEP, SL, RL, SFW, SDW, TD, TW, RD, and RW (Table 2).

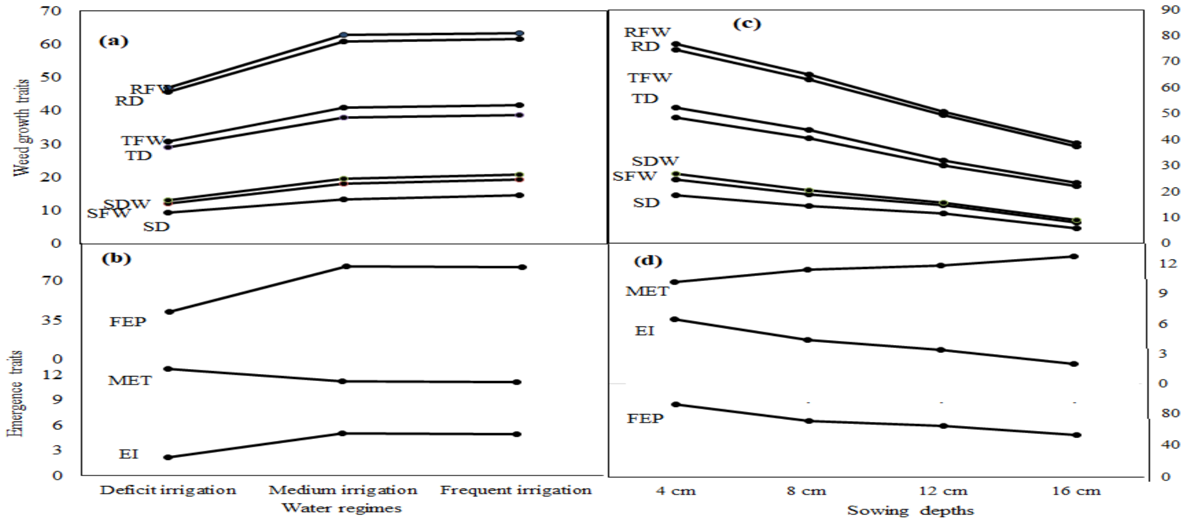

Figure. 5: Weed emergence traits, i.e. mean emergence time (MET), emergence index (EI), final emergence percentage (FEP) and growth traits i.e., shoot density (SD), shoot fresh weight (SFW), shoot dry weight (SDW), tuber density (TD), tuber fresh weight (TFW), root density (RD) and root fresh weight (RFW) with relation to various sowing depths and water regimes

RW, were decreased by increasing the sowing depths of *C. rotundus* (Figure 2, 3, and 4). Mean emergence time (MET) negatively correlated with the growth traits of *C. rotudus* (Table 1). (Roozkhosh et al., 2017) reported that *C. rotundus* growth (number of shoots and tuber) and emergence rate significantly decreased by increasing the sowing depths, as also found in this study (Figure 1, 2a, 3a). Increasing

Table 2. Correlation among emergence and growth traits of *C. rotundus i.e.* Emergence index (EI), final emergence percentage (FEP), mean emergence time (MET), root density (RD), shoot density (SD), shoot fresh weight (SFW), shoot dry weight (SDW), tuber density (TD), and tuber weight (TW).

Traits	EI	FEP	MET	RD	RW	SD	SDW	SFW	TW
FEP	0.8594***								
MET	-0.9008***	-0.8737***							
RD	0.8382***	0.7093**	-0.7768**						
RW	0.7705**	0.6909**	-0.7590**	0.9060***					
SD	0.8022***	0.6429**	-0.7376**	0.9166***	0.8070***				
SDW	0.9026***	0.7639**	-0.8605***	0.8482***	0.7454**	0.8857***			
SFW	0.9177***	0.8563***	-0.8688***	0.8824***	0.8201***	0.8639***	0.9207***		
TD	0.7853**	0.6854**	-0.7387**	0.8443***	0.7569**	0.9031***	0.8930***	0.8820***	
TW	0.7946**	0.6794**	-0.7415**	0.8431***	0.6996**	0.8919***	0.8937***	0.8529***	0.9589***

*** High correlations (values between 0.8 and 1). ** Moderate correlations (values between 0.5 and 0.7).

4. DISCUSSION

4.1. Effect of sowing depths on *C. rotundus* emergence and growth

Weed emergence traits, i.e., EI, FEP (Figure 1b-c), and growths characteristics such as SD, SFW, SDW, TD, TW, RD, and the sowing depth of the tuber significantly affects the emergence rate and the number of tubers, indicating that burying of tuber as deep as 8 cm slows the shoot emergence of tubers compared to a tuber buried at2.5 cm depth number [15]. Nutsedge rhizome was not survived at 30 cm depth with 60 C soil temperature (Daugovish et al., 2007). Reduction of *C. rotundus* infestation was observed in the field at the burial depth of the tuber is deeper than 30cm [15, 17]. Some studies reported that deep tillage with a moldboard plough may bury the weed seed at 18 to 25 cm sowing depth [18, 19]. The deep tillage plowing delayed the emergence and growth of purple nutsedge and decreased reproductive organ production as found in this study (Table 1, Figure 1, 2, 3, 4). (Nasab et al., 2019) conducted a pot study to check the effect of sowing depth on the growth of purple nutsedge. They found that with increasing the depths, all the growth traits of *C. rotundus* were significantly reduced. It is reported that 80% of the underground organ was formed at 2 to 12 cm depth. The 100% emergence percentage of tuber growth of weed reduced at 32 to 42 cm depth due to lack of light and distribution of gas exchanges (Nasab et al., 2019).

4.2. Effect of water regimes on plant growth and tuber

Increasing crop competitiveness is an important option for weed management. That can be achieved by nonchemical methods, e.g., cultural practices and precious application of water (Chauhan, 2020). *Cyperus rotundas* are dynamic and its performance affected by soil moister level. Weed emergence and growth traits such as shoot density and tuber production are significantly influenced by increasing the water deficit stress (Blaise et al., 2015). Increasing the deficit irrigation level drastically reduced EI, FEP (Figure 1b-c) and growth parameters (Figure 2, 3, 4). (Halli and Angadi, 2017) and (Halli et al., 2021) reported that appropriate moisture deficit is a viable option to suppress the weed and reduce water losses. Deficit irrigation of 24 to 40% less water can maintain productivity by suppressing weed competition (Coolong, 2013). Weeds are more efficient than crop plants for soil moisture availability. Weeds grow more vigorously and accumulate more dry matter than crops under moisture deficit conditions (Coolong, 2013). A similar finding was observed in this study (Figure 1a-c). It was observed that dry weight accumulation and weed flora growth was reduced by increasing the water deficit level (Abouziena et al., 2014), as seen in this study (Figure 2c, 3b, 4b, 5a). Le and Morell, (2021) reported that water shortage affected the quantity and biomass of purple nursedge tubers. A deficit moisture regime might have reduced the water uptake of weeds (Abouziena et al., 2014), as reported in this study (Figure 2c, 3b, and 4b). Similarly, accumulation of dry weight of weed increased with improved soil moisture availability (Halli et al., 2021), as observed in this study (Figure 2c, 3b, and 4b). Furthermore, in the peanut deficit, the irrigation from 100 to 40% declined by 25.66% weed dry weight (El-Metwally et al., 2020). It is because a plant's nutrient uptake depends on its water uptake ability. A higher degree of deficit irrigation can lead to lower uptake of NPK and poor mineralization, resulting in lower accumulation of weed dry weight (Li et al., 2007; Halli et al., 2021, Hasnain et al., 2021). Irrigation management is an important strategy for controlling and suppressed weed growth. Therefore, irrigation management with little stress should be promoted for good crop yield and lesser weed infestation. Deficit irrigation practices can mitigate the competitive effect of weeds with crops (Halli et al., 2021).

5. CONCLUSION

The sowing depth significantly influenced weed growth characteristics. The mean emergence time of *C. rotundus* seedlings increased by increasing the sowing depth to 16 cm. While deficit irrigation or water shortage also affected the emergence and growth traits of *C. rotundus*. Deficit irrigation treatment effectively controlled the *C. rotundus* growth by increasing the mean emergence time of seedlings. So, *C. rotundus* can be controlled by increasing the sowing depth with deficit irrigation.

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