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WEED FLORA, WEED SEED BANK AND PRODUCTIVITY OF RICE–MAIZE CROPPING SYSTEM AS INFLUENCED BY TILLAGE AND WEED MANAGEMENT PRACTICES IN CHHATTISGARH, INDIA

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ABSTRACT
A field experiment was conducted during the rice–maize cropping seasons of 2015-16 and 2016-17 at the Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, to evaluate tillage and weed management practices on weed dynamics, weed seed bank and yield of rice (*Oryza sativa* L.) and maize (*Zea mays* L.). The experiment was laid out in a split plot design with 3 replications. Treatments comprised 5 tillage practices in the main plots: CT – CT, CT – ZT, ZT – ZT, CT – ZT and CT – CT, and 3 weed management practices in the sub plots: oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize; pyrazosulfuron + pretilachlor 10 kg (G) ha^{-1} PE *fb* bispyribac-Na 25 g ha^{-1} PoE in rice and halosulfuron 60 g ha^{-1} PoE in maize; and an unweeded control. Both tillage and weed management practices exerted a significant influence on weed growth rate, weed seed bank and crop yield. Weed growth rate was lowest under CT – CT in rice and ZT – ZT in maize, and highest in the unweeded control. Weed seed numbers increased in the second year and declined with soil depth, being highest under ZT–ZT and lowest under CT–CT at 0–5 cm. Among weed management practices, oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize recorded the highest weed control efficiency (73.2% rice; 93.3% maize) and grain yield (4.98 and 4.51 t ha^{-1}), while the unweeded control produced the least (1.45 and 3.06 t ha^{-1}).

INTRODUCTION
Rice (*Oryza sativa* L.) and maize (*Zea mays* L.) together form the backbone of India's food and feed security, and their sequential cultivation has emerged as an important diversification pathway for resource-constrained cereal systems. Rice is grown on nearly 44 million ha with an average productivity of 2.2 t ha^{-1} (Rameshwar *et al.*, 2020). Maize production rose from 1.73 million MT in 1950–51 to 31.51 million MT by 2020–21, an almost 18-fold increase, while productivity improved from 547 to 2965 kg ha^{-1}, with about 83% of the maize area under *kharif* cultivation (Kaur *et al*., 2024). Maize now contributes roughly 9% of Indian food grain production, occupying 9.43 million ha with a production of 24.35 million MT (Sepat *et al*., 2019). Chhattisgarh, the "Rice Bowl of Central India," has about 4.82 million ha under rice with a production of 7.65 Mt (Murari *et al*., 2020), and rice is grown in approximately 3.8 million ha, over 80% of which is rainfed (Sinha *et al.,* 2019) (Shrivastava & Chaudhary, 2020). State productivity remains low, between 1.2 and 1.6 t ha^{-1} against a national average of 2.2 t ha^{-1}, and diversification toward maize has been recognized as a means of improving farm profitability (Singh *et al*., 2024). Regionally, rice–maize systems occupy more than 0.5 Mha of the 1.5 Mha under this system in South Asia, India accounts for around 0.53 Mha (Sahoo *et al*., 2025). Despite this potential, weeds remain a primary biotic constraint. *Echinochloa colona* and *Cyperus iria* are frequently recorded in the state's direct-seeded and transplanted rice fields, where competition for light, nutrients, water, and space can substantially reduce grain yield (Verma *et al*., 2025) (Mandle *et al*., 2025) (Babu, 2012), while *Alternanthera triandra* attains high density during critical growth stages (Meher *et al*., 2023) and *Medicago denticulata* intensifies weed–crop interference (Chitale & Tiwari, 2021). Their persistence is largely attributable to substantial soil seed banks that facilitate rapid decolonization (Sinha, 2017), and infestation is strongly modified by tillage and residue management, with surface residue retention reducing the density and biomass of both grass and broadleaf weeds (Kaur *et al*., 2021) (Bhargaw *et al*., 2023).

MATERIALS AND METHODS
Experimental site
The experiment was conducted at the Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India, during the rice–maize cropping seasons of 2015-16 and 2016-17. The experimental site is located at 21°4' N latitude, 81°35' E longitude, at an altitude of approximately 290.20 m above mean sea level. The experimental soil was sandy loam in texture, with sand 21.88 and 21.75%, silt 40.66 and 40.71%, and clay 37.46 and 37.54% in the two years, respectively. Bulk density was 1.51 and 1.45 Mg m^{-3}, and the soil was

low in organic carbon (0.46 and 0.42 g kg^{-1}) and available nitrogen (220 and 216 kg ha^{-1}), medium in available phosphorus (20 and 18 kg ha^{-1}), and high in available potassium (320 and 321 kg ha^{-1}). The pH was 7.5 and 7.3 (neutral) and the electrical conductivity 0.45 and 0.41 dS m^{-1} (normal) during 2015-16 and 2016-17, respectively.

Climatic conditions

Meteorological data were recorded weekly during 2015-16 and 2016-17. *Kharif* rainfall was 816.6 mm (2015) and 1135 mm (2016), poorly distributed in 2015, when vegetative-stage rainfall was less than in 2016. Rice-season weekly maximum and minimum temperatures ranged 33.7–28.7 °C and 25.9–20.9 °C in 2015, and 36.5–28.5 °C and 18–26.7 °C in 2016; maximum relative humidity varied 77–94% and 96–81%, and minimum 40–82% and 33–84%. Pan evaporation ranged 2.4–9.2 and 2.6–6.3 mm day^{-1}, sunshine 0.3–8.6 and 0.6–8.2 hour's day^{-1}, and wind velocity 2.2–10.6 and 1.1–9.2 km hr^{-1}, respectively. Maize-season rainfall totalled 25.0 mm (2015-16) and 0.0 mm (2016-17), the second *rabi* being rainless. Weekly maximum and minimum temperatures ranged 27.1–32.9 °C and 27.8–9.0 °C in 2015-16, and 27.7–42.3 °C and 25.9–8.9 °C in 2016-17. Maximum relative humidity ranged 44–99% and 90–32%, minimum 14–53% and 23–36%, pan evaporation 2.2–6.7 and 2.8–9.5 mm day^{-1}, sunshine 2.1–10.8 and 6.4–10.2 hours day^{-1}, and wind velocity 2.0–6.4 and 1.0–4.8 km hr^{-1}, respectively.

Experimental treatment and design

The experiment was laid out in a split plot design (SPD) with 3 replications. The 5 level of tillage practices were placed under main plots, whereas sub plots were occupied with 3 levels of weed management practices.

Main plot treatments (Tillage practices)

$T_{1:}$ Conventional tillage (DSR) + Conventional tillage
$T_{2:}$ Conventional tillage (DSR) + Zero tillage
$T_{3:}$ Zero tillage (DSR) + Zero tillage
$T_{4:}$ Conventional tillage (TPR) + Zero tillage
T_5 : Conventional tillage (TPR) + Conventional tillage

Sub plot treatments (Weed management practices)

$W_{1:}$ Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize
W_2: Pyrazosulfuron + pretilachlor 10 kg (G) ha^{-1} PE *fb* bispyribac - Na 25 g ha^{-1}PoE in rice and halosulfuron 60 g ha^{-1} PoE in maize
$W_{3:}$ Unweeded

Data collection and observations

Weed density and weed dry matter production were used to determine weed growth rate (WGR) weed control efficiency (WCE) (5). Observations on crop growth and yield parameters were systematically recorded during both 2015-16 and 2016-17.

Weed seed bank study

Sampling of weed seed bank was done in the end of each cropping cycle in 2015-16 to 2016-17 just after harvest of rice and maize crop. In each plot five areas were sampled using a 4 cm diameter metal core. For each area, the core was used to carefully excavate soil from the 0 to 5, 5 to 10 and 10 to 20 cm soil depths. All samples for a given depth were bulked to give a composite soil sample $plot^{-1}$. Bulked soil samples were partially air-dried and then clods were broken by hand. The soil seed bank was estimated by the seedling emergence method as described by Heerdt *et al.* (1996). This method can underestimate the absolute weed seed bank size, but provides a relative comparison to assess tillage effects. Three 500 g soil samples for each depth $plot^{-1}$ were prepared. These soil samples were spread in a plastic pot and placed in a field condition and watered daily. The emerged weed seedlings were identified, counted, and removed until emergence was nil. Soil was then dried, rewatered and stirred to initiate further emergence. This cycle was repeated approximately monthly through July to November and December to March. Estimation of the vertical distribution of the weed seeds was made from the number of seedlings that emerged from the soil cores of different depths. Number of weed seed converted 500 gm soil sample to 1000 gm for statistical analysis.

Statistical analysis

Analysis of variance (ANOVA) was carried out for the split- plot design using statistical outlined earlier and treatment effects were tested for significance at the 5 % probability level (6)

RESULTS AND DISCUSSION

Weed flora

In the agro-climatic conditions of Chhattisgarh, these species locally recognized as significant threats including *Echinochloa colona* (jungli sawa) and *Cyperus iria* (rice flatsedge) exert considerable competitive pressure on staple cereal production. In particular, *Echinochloa colona* and *Cyperus iria* are frequently recorded in Chhattisgarh's direct seeded and transplanted rice fields, where competition for light, nutrients, water, and space can substantially reduce rice grain yield (Verma *et al*., 2025). Similarly, *Alternanthera triandra*, often known as sessile joyweed, exhibits high density during critical growth stages in regional rice systems, consistently ranking among the most prominent weed species (Meher *et al*., 2023). *Medicago denticulata*, commonly referred to as burr medic, often establishes in similar agro-ecosystems, further intensifying weed-crop interference that limits the growth potential of maize and rice (Chitale & Tiwari, 2021). Specifically, *Cyperus iria*, a prevalent sedge species, frequently occurs alongside *Echinochloa colona* in regional crop fields, significantly hindering crop productivity (Raj *et al*., 2022). (Photo 1.0) These invasive taxa compete aggressively with maize and rice for soil

resources, with studies documenting that such infestations remain a primary driver of yield degradation within the state's diverse agro-ecosystems (Kaushal *et al*., 2025). Effective mitigation of these infestations necessitates early season weed control strategies, as monocot species like *Echinochloa colona* and *Cyperus iria* demonstrate a high capacity to suppress crop biomass development (Patidar *et al*., 2023). The persistent nature of these weeds is largely attributed to substantial soil seed banks, which facilitate rapid colonization and severe competition throughout the cropping cycle (Sinha, 2017). Integrated weed management practices, such as the strategic application of herbicides like bispyribac sodium, have proven essential in mitigating these competitive effects and restoring yield potential in direct-seeded systems (Verma *et al*., 2023). Furthermore, localized research within Chhattisgarh indicates that implementing timely hand weeding, particularly at 20, 40, and 60 days after sowing, remains a highly effective mechanism for reducing the dry biomass of these competitive species (Janghel *et al*., 2025). Such integrated control measures are critical, as the proliferation of these weeds significantly restricts the availability of nitrogen and phosphorus to the crop, directly hindering grain formation and overall photosynthetic efficiency. The prevalence of these weeds in rice-maize systems necessitates a multifaceted approach, as uncontrolled weed populations can result in substantial yield losses, sometimes exceeding 50% depending on the intensity of the competition (Das *et al*., 2024).(Photo 1.0)

The magnitude of this weed pressure, however, is strongly modified by tillage and residue management, which together determine the soil micro environment in which these species establish. The shift from intensive tillage to conservation tillage induces major changes in weed dynamics and herbicide efficacy, and rice residue retention on the surface reduces the density and biomass of both grass and broadleaf weeds relative to its removal (Kaur *et al*., 2021). In residue-retained zero-tillage systems, surface retention of rice straw at 5 t ha^{-1} decreased weed population by up to 60–75%, while the performance of zero tillage improved by 3–4% over all other treatments in the second year (Bhargaw *et al*., 2023). The mechanism underlying such suppression is partly physical and partly allelopathic rice residue on the soil surface blocks light, imposes mechanical impedance on emerging seedlings, and releases phytotoxic chemicals that inhibit weed germination, thereby lowering both weed density and weed dry weight (Puniya *et al*., 2023). Comparable effects have been recorded in conservation rice–wheat systems, where rice residue mulch retention in no-tilled wheat decreased weed density and weed dry weight by 60 and 69%, respectively, compared with no mulch (Nawaz *et al*., 2016).

Within the rice–maize rotation specifically, the combination of tillage and residue retention plays a decisive role in weed population and weight. Under a two-year rice–maize rotation, total weed density and biomass in both rice and maize at 30 days after sowing were lowest in permanent beds under zero-tillage with residue retention (50% rice residue retention for maize and 25% maize residue retained for rice) compared with other tillage and residue-management combinations, including the conventional puddled transplanted system (Sahoo *et al*., 2024, 2025). Transplanting, by contrast, does not by itself confer a weed suppressive advantage once puddling is involved; while zero-tilled dry-seeded rice recorded higher aboveground weed density in the first year, the same system registered the lowest total viable seed density over both years, and monocotyledonous species such as *Leptochloa chinensis* were markedly more dominant under zero-tillage, indicating a shift in weed community composition rather than a uniform reduction in population. Complete zero-tillage practices with crop residue, moreover, significantly enhanced the grain yield of component crops over conventional puddled transplanted rice and maize, suggesting that exhaustion of the soil seed bank under continuous zero-tillage can progressively reduce aboveground weed infestation and restore yield potential (Nandan *et al*., 2020). These tillage- and residue-mediated differences in weed population and weed weight therefore constitute an important axis of variation in the rice–maize system of Chhattisgarh, and must be accounted for when interpreting the density and competitive impact of *Echinochloa colona*, *Cyperus iria*, *Alternanthera triandra* and *Medicago denticulata* across seasons.

Weed growth rate

Weed growth rate in rice varied markedly with tillage and weed management. It was lowest under CT–CT at all intervals (means 0.08, 0.97, 1.13 and 0.57 g day^{-1} m^{-2}) and highest under CT–ZT (0.32, 2.06, 2.59 and 0.69). Among weed management practices, oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE recorded the lowest rates (0.05, 0.84, 1.03 and 0.37), while the unweeded control recorded the highest (0.53, 2.81, 3.66 and 1.10). Growth rate peaked at 40–60 DAS/T and was generally higher in 2015 than 2016 (Table 1.0). Weed growth rate in maize increased progressively with crop age, peaking at 60 DAS–harvest. Among tillage practices, ZT–ZT recorded the lowest rates (means 0.55, 1.08, 1.32 and 2.14 g day^{-1} m^{-2}), whereas CT–CT recorded the highest (0.62, 1.28, 1.97 and 2.44). Atrazine 1.0 kg ha^{-1} PE recorded the lowest rates (0.12, 0.20, 0.31 and 0.45), and the unweeded control the highest (1.41, 3.03, 3.92 and 5.37). Rates were higher in 2016-17 than 2015-16 (Table 1.0).

Weed seed bank

Echinochloa colona seed numbers rose in the second year across treatments and declined with soil depth. At 0–5 cm, ZT–ZT recorded the most seeds (7.67 and 25.56 kg^{-1} soil) and CT–CT the least (4.78 and 14.56). Herbicidal programmes (Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize) markedly reduced seeds versus the unweeded control (10.67 and 32.60 kg^{-1} soil).***Alternanthera triandra*** seeds increased in the second year across treatments and declined with soil depth. At 0–5 cm, ZT–ZT recorded the most seeds (7.89 and 10.11 kg^{-1} soil) and CT–CT the least (3.89 and 6.33). At 5–10 cm, CT–CT peaked (6.11 and 9.11) while ZT–ZT was lowest. Herbicidal treatment (Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize) markedly reduced seeds versus the unweeded control. ***Medicago denticulata*** seed numbers increased in the second year across treatments. At 0–5 cm, ZT–ZT recorded the most seeds (5.00

and 7.56 kg⁻¹ soil) and CT–CT the least (2.44 and 4.11); at 5–10 cm, CT–CT peaked (5.33 and 8.78) while ZT–ZT was lowest (2.89 and 4.00). The unweeded control (6.33 and 9.80) exceeded all herbicidal treatments, with oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize giving the fewest seeds at every depth. ***Cyperus iria*** seed numbers increased in the second year across treatments and declined with soil depth. At 0–5 cm, ZT–ZT recorded the most seeds (14.11 and 20.00 kg⁻¹ soil) and CT–CT the least (8.33 and 11.44). Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize minimized seeds (7.33 and 10.40) versus the unweeded control (15.27 and 22.20). **Total weed seed bank** was lower in the first year and increased during the second year in all treatments, being highest in the 0–5 cm layer and declining with increasing soil depth. At 0–5 cm, ZT–ZT recorded the highest seeds (34.67 and 63.22 kg⁻¹ soil, first and second year, respectively), while CT–CT recorded the lowest (19.44 and 36.44 kg⁻¹ soil). At 5–10 cm, CT–ZT was highest (23.89 and 41.44 kg⁻¹ soil), at par with CT–CT (23.67 and 40.89) and CT–ZT. At 10–15 cm, CT–CT peaked (11.61 and 19.56 kg⁻¹ soil), whereas CT–ZT was lowest (10.56 and 16.00). Under weed management oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize recorded the fewest seeds at 0–5 cm (16.13 and 29.47 kg⁻¹ soil), at par with the pyrazosulfuron + pretilachlor 10 kg (G) ha^{-1} PE *fb* bispyribac - Na 25 g ha^{-1}PoE in rice and halosulfuron 60 g ha^{-1} PoE in maize, both significantly superior to the unweeded control (42.07 and 78.27 kg⁻¹ soil). The tillage × weed-management interaction influenced the seed bank in both years. These trends corroborate established weed seed bank ecology ZT retains the largest portion of seeds in the surface layers up to 90% within 0–5 cm whereas ploughing distributes seeds more uniformly through the profile, placing most seeds in deeper layers (Feledyn Szewczyk *et al.,* 2020). Competition from surface-retained residues and predator activity further deplete surface seeds under zero tillage, predation being consistently greater in ZT than in conventional tillage (Kanomanyanga *et al*., 2026), while conventional soil inversion reduces such losses by burying seeds below the reach of granivores and herbicide action (Bàrberi & Cascio, 2001). (Graph 1.0)

Grain yield (t ha^{-1}) and weed control efficiency (%)

Rice grain yield differed significantly among tillage practices, being highest under CT (TPR) - CT (mean 4.45 t ha⁻¹) and CT (TPR) - ZT (4.29 t ha⁻¹) and lowest under CT (DSR) - ZT (2.95 t ha⁻¹). Maize responded differently, yielding most under CT (DSR) - CT (4.16 t ha⁻¹) and least under CT (TPR) - CT (3.39 t ha⁻¹). Among weed-management treatments, Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize recorded the highest grain yield in both rice (4.98 t ha⁻¹) and maize (4.51 t ha⁻¹), while Unweeded control produced the least (1.45 and 3.06 t ha⁻¹), reflecting the strong competitive penalty imposed by weeds (Verma *et al*., 2025). Weed control efficiency was highest under CT (DSR) – CT (72.7% rice; 91.4% maize) and Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize (73.2% rice; 93.3% maize), and lowest under CT (DSR) - ZT and Pyrazosulfuron + pretilachlor 10 kg (G) ha^{-1} PE *fb* bispyribac - Na 25 g ha^{-1}PoE in rice and halosulfuron 60 g ha^{-1} PoE in maize. The significant T×W interaction for rice yield in both years and for maize in 2016-17 indicates that tillage benefits were realised only where weeds were adequately suppressed. Residue-retained zero-tillage plots supported better yields through reduced weed interference (Sahoo *et al*., 2024, 2025), consistent with reports that residue retention lowers weed density and biomass (Bhargaw *et al*., 2023) and that conservation tillage alters weed dynamics and productivity (Kaur *et al*., 2021). (Table 3.0)

CONCLUSION

The combined method of using a CT (TPR) – CT in rice and CT (DSR) – CT in Maize Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize was found to be the most effective in suppressing diverse weed flora, resulting in the highest rice and maize yield and emerging as a technically sound and financially feasible tillage and weed management strategy.

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Echinochloa colona iria

Alternanthera triandra

Medicago denticulate

Cyperus

Photo 1.0 Weed Flora

Table 1.0: Weed growth rate in rice as influenced by tillage and weed management practices in rice - maize cropping system

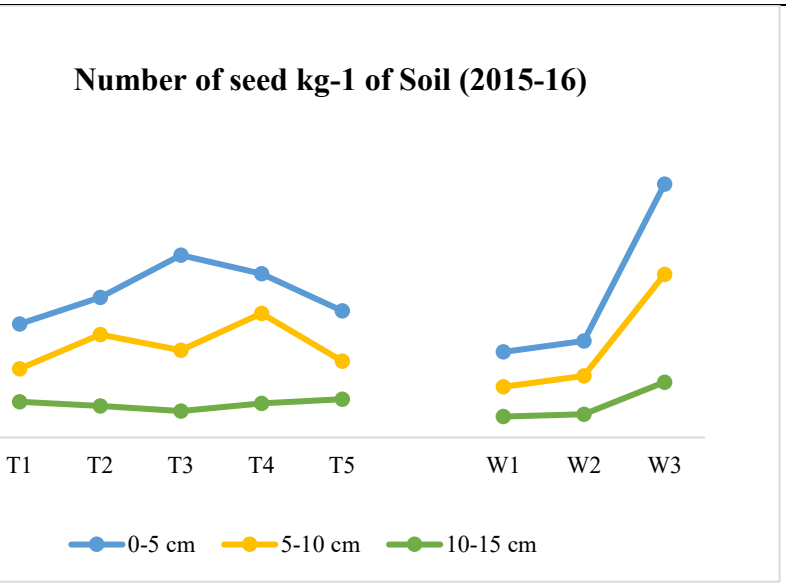
Treatment	Weed growth rate (g day^{-1} m^{-2})											
	0-20 DAS/T			20-40 DAS/T			40-60 DAS/T			60 DAS/T -At harvest		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
Tillage practices												
CT (DSR) - CT	0.35	0.28	0.31	2.02	1.85	1.94	3.00	2.16	2.58	0.65	0.73	0.69
CT (DSR) - ZT	0.35	0.29	0.32	2.13	1.99	2.06	3.00	2.17	2.59	0.65	0.73	0.69
ZT (DSR) - ZT	0.39	0.14	0.26	2.17	1.36	1.76	3.02	1.78	2.40	0.66	0.64	0.65
CT (TPR) - ZT	0.10	0.07	0.09	1.08	0.96	1.02	1.31	1.02	1.16	0.58	0.61	0.60
CT (TPR) - CT	0.10	0.07	0.08	1.02	0.91	0.97	1.28	0.97	1.13	0.55	0.59	0.57
Weed management												
Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE	0.06	0.04	0.05	0.90	0.78	0.84	1.09	0.96	1.03	0.39	0.35	0.37
Pyrazosulfuron + pretilachlor 10 kg (G) ha^{-1}PE *fb* bispyribac-Na 25 g ha^{-1} PoE	0.08	0.05	0.07	1.06	0.93	1.00	1.36	1.10	1.23	0.44	0.45	0.45
Unweeded control	0.63	0.43	0.53	3.09	2.54	2.81	4.52	2.80	3.66	1.02	1.18	1.10

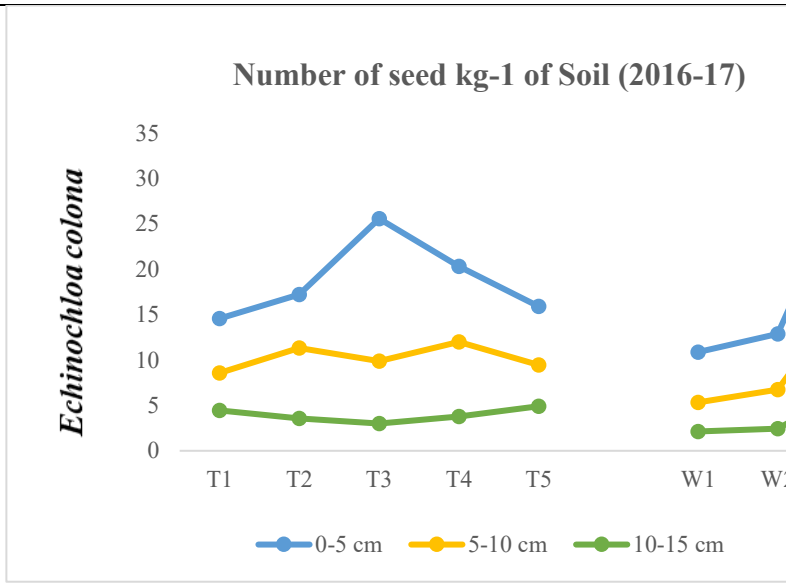
Table 2.0: Weed growth rate in maize as influenced by tillage and weed management practices in rice - maize cropping system

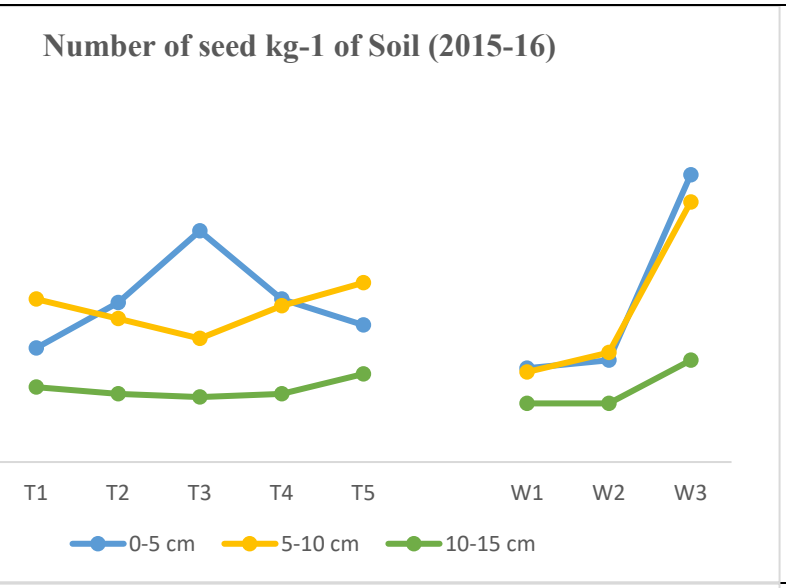
Treatment	Weed growth rate (g day^{-1} m^{-2})											
	0-20 DAS			20-40 DAS			40-60 DAS			60 DAS-at harvest		
	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
Tillage practices												
CT (DSR) - CT	0.57	0.57	0.57	1.06	1.22	1.14	1.66	1.84	1.75	2.07	2.24	2.16
CT (DSR) - ZT	0.60	0.67	0.63	1.10	1.38	1.24	1.43	1.73	1.58	2.05	2.44	2.24
ZT (DSR) - ZT	0.52	0.57	0.55	0.99	1.18	1.08	1.26	1.37	1.32	2.05	2.23	2.14
CT (TPR) - ZT	0.66	0.74	0.70	1.21	1.51	1.36	1.50	1.83	1.67	2.18	2.60	2.39
CT (TPR) - CT	0.62	0.63	0.62	1.17	1.39	1.28	1.84	2.11	1.97	2.30	2.58	2.44
Weed management												
Atrazine 1.0 kg ha^{-1}PE	0.11	0.12	0.12	0.20	0.21	0.20	0.30	0.31	0.31	0.46	0.45	0.45
Halosulfuron 60 g ha^{-1}PoE	0.31	0.33	0.32	0.41	0.46	0.43	0.71	0.78	0.74	0.96	1.04	1.00
Unweeded control	1.36	1.46	1.41	2.72	3.35	3.03	3.60	4.24	3.92	4.98	5.77	5.37

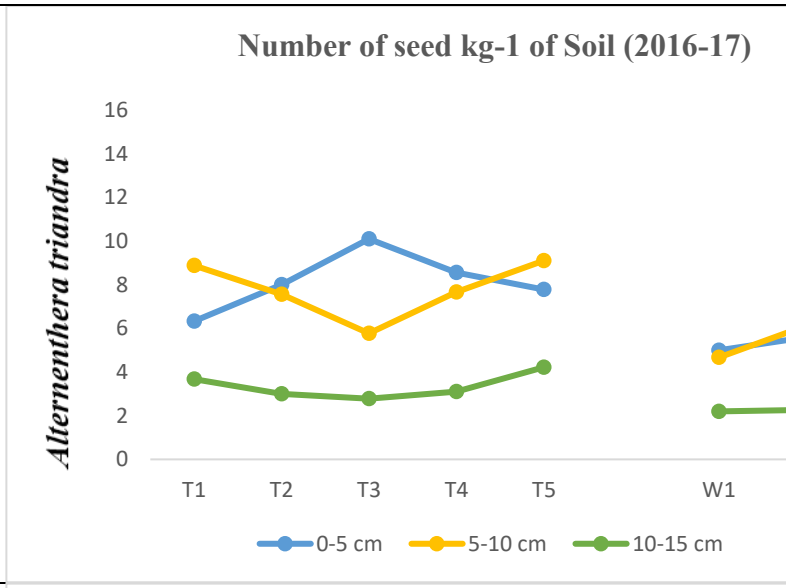
Table 3.0: Grain yield (t ha^{-1}) and Weed control efficiency (%) at 40 DAS/T in rice and maize as influenced by tillage and weed management practices in rice - maize cropping system

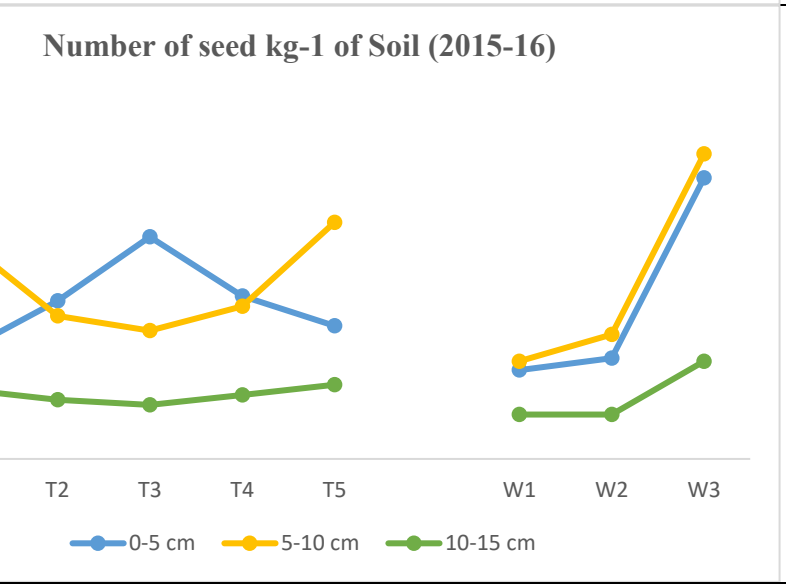
Treatment	Grain yield (t ha^{-1})						Weed control efficiency (%) at 40 DAS/T					
	Rice			Maize			Rice			Maize		
	2015	2016	Mean	2015-16	2016-17	Mean	2015	2016	Mean	2015-16	2016-17	Mean
Tillage practices												
CT (DSR) - CT	2.98	3.20	3.09	4.51	3.82	4.16	72.9	72.4	72.7	90.4	92.3	91.4
CT (DSR) - ZT	2.88	3.01	2.95	4.31	3.61	3.96	71.9	69.5	70.7	87.8	88.4	88.1
ZT (DSR) - ZT	2.83	3.76	3.30	4.40	3.76	4.08	71.6	64.8	68.2	87.6	88.1	87.9
CT (TPR) - ZT	4.15	4.43	4.29	3.83	3.18	3.51	69.5	70.1	69.8	88.7	89.4	89.1
CT (TPR) - CT	4.37	4.53	4.45	3.67	3.11	3.39	69.6	70.6	70.1	89.9	92.0	91.0
SEm±	**0.09**	**0.10**	**0.08**	**0.11**	**0.10**	**0.10**						
CD (P=0.05)	**0.31**	**0.32**	**0.25**	**0.37**	**0.31**	**0.33**						
Weed management												
Oxadiargyl 90 g ha^{-1} PE *fb* pinoxsulam 22.5 g ha^{-1} PoE in rice and atrazine 1.0 kg ha^{-1} PE in maize	4.77	5.19	4.98	4.85	4.16	4.51	73.8	72.5	73.2	92.8	93.8	93.3
Pyrazosulfuron + pretilachlor 10 kg (G) ha^{-1} PE *fb* bispyribac - Na 25 g ha^{-1}PoE in rice and halosulfuron 60 g ha^{-1} PoE in maize	4.27	4.56	4.42	4.24	3.55	3.90	68.4	66.5	67.5	84.9	86.4	85.7
Unweeded control	1.28	1.61	1.45	3.34	2.78	3.06	-	-	-	-	-	-
SEm±	**0.05**	**0.05**	**0.04**	**0.08**	**0.05**	**0.06**						
CD (P=0.05)	**0.15**	**0.15**	**0.12**	**0.22**	**0.16**	**0.17**						
T×W	**S**	**S**	**S**	**NS**	**S**	**S**						

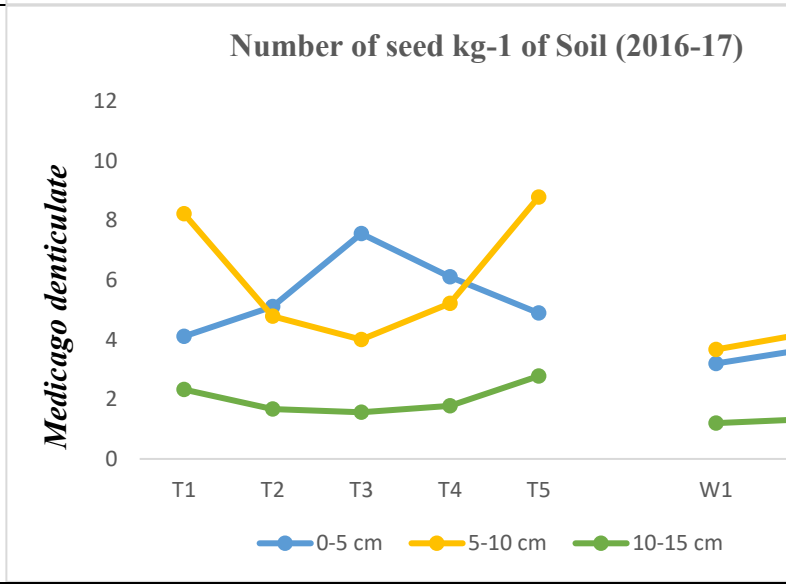

Number of seed kg-1 of Soil (2015-16)
T1
T2
T3
T4
T5
W1
W2
W3
0-5 cm
5-10 cm
10-15 cm

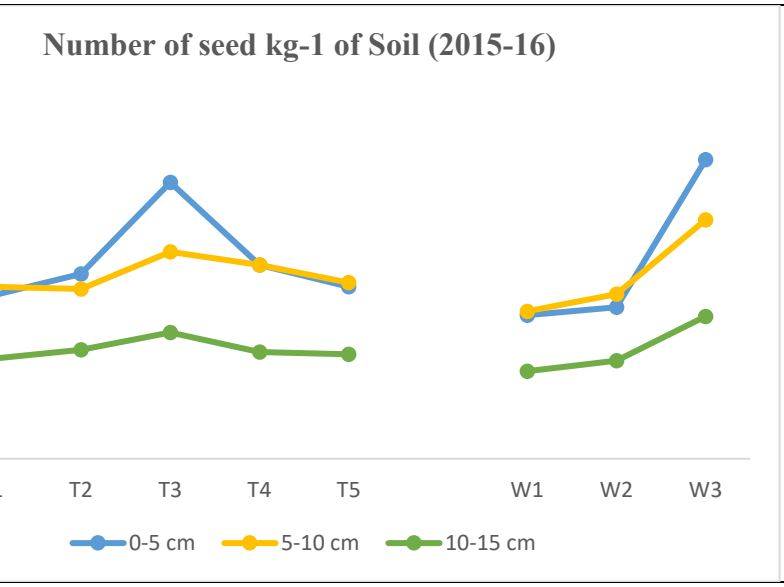

Number of seed kg-1 of Soil (2016-17)
Echinochloa colona
35
30
25
20
15
10
5
0
T1
T2
T3
T4
T5
W1
0-5 cm
5-10 cm
10-15 cm

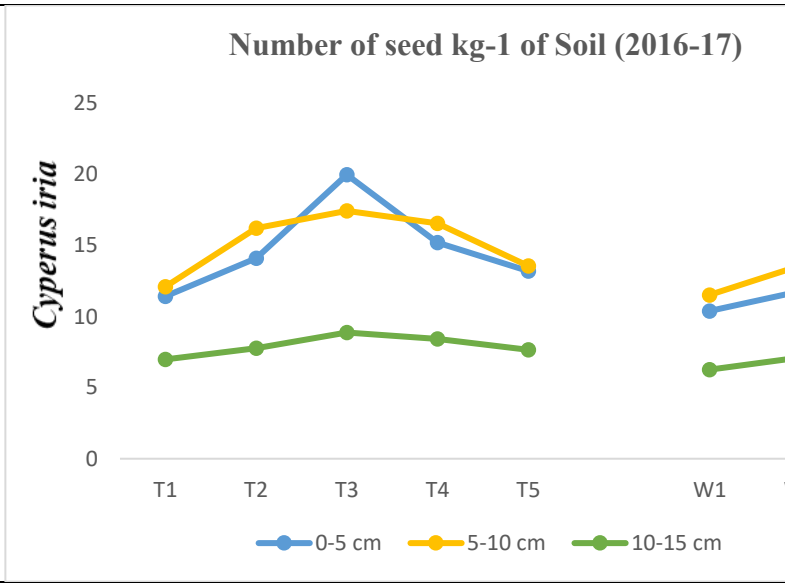

Number of seed kg-1 of Soil (2015-16)
T1
T2
T3
T4
T5
W1
W2
W3
0-5 cm
5-10 cm
10-15 cm

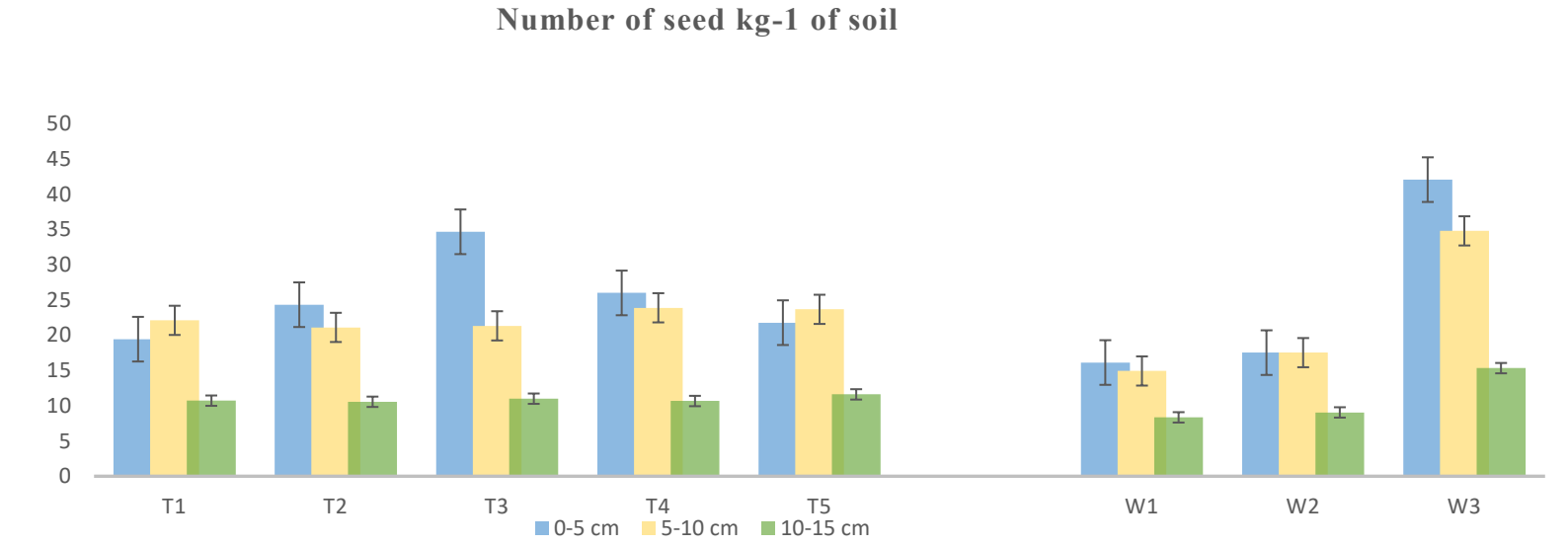

Number of seed kg-1 of Soil (2016-17)
Alternenthera triandra
16
14
12
10
8
6
4
2
0
T1
T2
T3
T4
T5
W1
0-5 cm
5-10 cm
10-15 cm


Number of seed kg-1 of Soil (2015-16)
T2
T3
T4
T5
W1
W2
W3
0-5 cm
5-10 cm
10-15 cm


Number of seed kg-1 of Soil (2016-17)
Medicago denticulate
12
10
8
6
4
2
0
T1
T2
T3
T4
T5
W1
0-5 cm
5-10 cm
10-15 cm







Seed bank of weed seeds as influenced by tillage and weed management practices in rice - maize cropping system