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Research Article

# Growth Parameters of Rice (*Oryza sativa*) as Influenced by Tillage and Weed Management Practices in Rice-Maize-Greenmanure System Under Conservation Agriculture

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## Abstract

Crop management practices highly influences the profitability of rice production. Tillage and weed management practices effects the growth of rice and ultimately final yield. In order to evaluate the influence of different Tillage and weed management practices on various growth parameters of transplanted as well as direct seeded rice under rice-maize-greenmanure system, a field experiment was conducted during kharif-2018 in the field of AICRP on Weed Management, College of Agriculture, Professor Jayashankar Telanagana State Agricultural University, Hyderabad. The experiment was laid out in split plot design with five main plots, three sub-plots and three replications. The main plots included five tillage practices such as i) conventional tillage transplanted rice *fb* conventional tillage maize, ii) Conventional tillage transplanted rice *fb* zero tillage maize, iii) conventional tillage direct seeded rice *fb* conventional tillage maize, iv) zero tillage direct seeded rice *fb* zero tillage maize with residue cover and v) zero tillage direct seeded rice with residue cover *fb* zero tillage maize with residue cover and sub plots including three weed management practices i.e., chemical weed management with recommended herbicides, Integrated Weed Management (IWM) and unweeded control. In terms of plant height, tillers and dry matter, transplanted rice performed well compared to direct seeded rice irrespective of tillage practice adopted. Among direct seeded rice treatments, conventional tillage direct seeded rice proven to be better than zero tillage direct seeded rice. Integrated Weed Management was proven to be superior than chemical weed management in terms of tiller production and dry matter production whereas Plant height was comparable between chemical weed management and Integrated Weed Management. Transplanted rice proven to be superior than direct seeded rice irrespective of tillage and weed management practices. The results showed that Conventional tillage combined with Integrated weed management resulted in superior growth parameters in both transplanted rice as well as direct seeded rice. .

**Keywords:** Direct Seeded Rice; Residue Cover; Zero Tillage; Integrated Weed Management; Conventional Tillage; *Sesbania*

## Abbreviations

TPR: Transplanted Rice; DSR: Direct Seeded Rice; CT: Conventional Tillage; ZT: Zero Tillage; PE: Pre-Emergence; PoE: Post-Emergence; IWM: Integrated Weed Management; HW: Hand Weeding; +R: Residue Cover; DAT: Days After Transplanting: *fb*: Followed By

## Introduction

The area under rice cultivation in India accounts for 44.16 M ha with an average production of 116.48 M t with productivity of 2.63 t $ha^{-1}$. Out of the total area of rice grown 85% is transplanted rice and 12% is under upland direct seeded rice. In Telangana, total

area under rice cultivation is 1.93 M ha with production of 6.67 M tonnes and productivity of 3.45 t $ha^{-1}$ during 2018-19 [1]. In India, rice is cultivated by transplanting 25-30 days old seedlings in the puddled field. The advantage of puddling is effective weed control, reduces percolation, improves nutrient availability by creating anaerobic conditions and facilitates easy seedling establishment. Besides these advantages, the main disadvantage is higher requirement of labour, water etc. and this led to a substantial rise in the production cost [2]. These factors necessitated several researchers to study the possibility of rice cultivation under irrigated dry conditions. Direct seeded rice (DSR) can be sown under conventional tillage or under zero-till conditions. The main advantage is it requires less labor and fuel compared to conventional tillage systems. When rainfall at planting time is highly variable, direct seeding may help reduce the production risk [3]. But the yields of DSR are reduced due to heavy weed infestations. Weed control is a challenge in DSR systems because of the diversity and severity of weed infestation.

"Conservation agriculture (CA) is a resource saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving environment" (FAO, 2007). The main principles of conservation agriculture include reduced tillage systems, permanent soil cover, effective use of crop rotations including intercrops and cover crops and reducing the fallow period. In low intensity tillage or no tillage associated with conservation agriculture weeds are the major biological constraints towards the large scale adoption of it [4]. One of the ways to control weeds is to use the selective herbicides. Thus, post-emergence spray of such herbicides will help to manage weeds. Hence, in order to achieve maximum production from low tillage systems or direct seeded rice systems proper control of weeds is necessary to achieve acceptable profits. The present investigation is carried out to know effect of different tillage and weed management practices on growth of transplanted and dry direct seeded rice.

## Materials and Methods

### Site description

A field experiment was conducted during *kharif*-2018, at AICRP on Weed Management, College of Agriculture, Professor Jayashankar Telanagana State Agricultural University, Hyderabad, Telangana, India (17°19' N and 78°24' E). The field was under conservation agriculture with rice-maize-greenmanure system since 5 years. The present study was in fifth year of experimentation in rice.

### Treatment details

The experiment was laid out in split plot design with three replications. Main plot treatments were five tillage practices and subplot treatments were three weed management practices. Five tillage practices included i) conventional tillage transplanted rice *fb* conventional tillage maize in rabi and fallow in summer (CT - CT of TPR) ii) conventional tillage transplanted rice *fb* zero tillage maize in rabi (CT - ZT of TPR) and green manure (*Sesbania*) in summer iii) conventional tillage direct seeded rice *fb* conventional tillage maize (CT - CT of DSR) in *rabi* and green manure in summer iv) zero tillage direct seeded rice *fb* zero tillage maize in *rabi* (ZT - ZT of DSR) and green manure in summer v) zero tillage direct seeded rice with residue cover *fb* zero tillage maize with residue cover (ZT+R - ZT+R of DSR) in *rabi* and green manure in summer. Weed management practices included i) chemical weed management *i.e.,* Bensulfuron methyl (0.6% ) + pretilachlor (6%) 0.66 kg $ha^{-1}$ as PE at 3-5 DAT *fb* bispyribac sodium 10% SC 25g $ha^{-1}$ as PoE at 2-3 weed leaf stage for transplanted rice whereas Pendimethalin 30% EC 1000g $ha^{-1}$ as PE *fb* bispyribac sodium 10% SC 25g $ha^{-1}$ as PoE at 2-3 weed leaf stage for direct seeded rice ii) Integrated weed management *i.e.,* Bispyribac sodium 10% SC 25 g $ha^{-1}$ as early PoE at 2-3 weed leaf stage *fb* HW at 40 DAT and iii) Unweeded control. For residue cover treatments previous season green manure was spread as mulch in between rows of current season crop.

### Crop management

Rice variety MTU-1010 was sown with a seed rate of 50 kg $ha^{-1}$ in case of transplanted rice and 70 kg $ha^{-1}$ in case of dry direct seeded rice, spacing of 20 X 10 cm was followed. 30 days old rice seedlings were transplanted in the main field for transplanted rice. For dry direct seeded rice, seeds were directly sown in plots by line sowing.

Recommended fertilizer dose 120 kg N + 60 kg P + 40 kg K to transplanted rice and 100 kg N + 50 kg P + 50 kg K to direct seeded rice was applied. The Remaining agronomic practices were carried out as per the recommendations.

Observations on growth parameters *i.e.,* plant height, tillers and dry matter production were recorded at tillering, panicle initiation, grain filling and at harvest stages of the crop

## Results and Discussion

### Effect on plant height

Plant height, a growth parameter mainly governed by many factors such as light, space, water and nutrients. Plant height was significantly influenced by tillage and weed management practices and is presented in table 1.

Plant height recorded under CT - CT and CT - ZT of transplanted rice was comparable to each other and significantly superior to plant height recorded in direct seeded rice under different methods of tillage. In direct seeded rice, CT - CT recorded higher plant height than the zero tillage rice. Zero tillage rice with and without residue cover recorded comparable plant height and inferior than

| Treatments | Plant height (cm) | | | |
|---|---|---|---|---|
| | Tillering stage | Panicle initiation | Grain filling | Harvest |
| Tillage practices (Main plots) | | | | |
| $T_1$ CT (Transplanted) - CT (maize) | 39.84 | 70.00 | 90.57 | 92.22 |
| $T_2$ CT (Transplanted) - ZT (maize) | 39.29 | 68.77 | 88.97 | 91.17 |
| $T_3$ CT (DSR) - CT (maize) | 36.79 | 55.33 | 64.45 | 65.50 |
| $T_4$ ZT (DSR) - ZT (maize) | 35.33 | 47.28 | 53.69 | 54.89 |
| $T_5$ ZT+R (DSR) - ZT+R (maize) | 35.22 | 48.81 | 54.47 | 56.06 |
| SE(m)± | 0.39 | 0.50 | 0.34 | 0.37 |
| CD (P=0.05) | 1.30 | 1.65 | 1.13 | 1.23 |
| Weed management practices (Sub plots) | | | | |
| $W_1$ - Chemical management | 37.88 | 59.34 | 72.41 | 73.93 |
| $W_2$ - IWM | 37.48 | 59.94 | 72.58 | 74.70 |
| $W_3$ - Unweeded control | 36.52 | 54.84 | 66.30 | 67.27 |
| SE(m)± | 0.331 | 0.31 | 0.29 | 0.43 |
| C.D | 0.984 | 0.91 | 0.86 | 1.28 |
| Interaction | | | | |
| T×W | NS | NS | NS | NS |

**Table 1:** Plant height (cm) of rice as influenced by tillage and weed management practices at different stages under conservation agriculture.

CT: Conventional Tillage; TPR: Transplanted Rice; DSR: Direct Seeded Rice; ZT: Zero Tillage; R: Residue Cover

rest of the treatments at all the observational stages. Weed management practices also significantly influenced the plant height and highest plant height was recorded in IWM which was comparable to chemical weed management. However, unweeded control registered significantly lowest plant height at all stages of crop. Interaction effect of tillage and weed management practices on plant height was found to be non-significant.

CT - CT, CT - ZT of TPR, and CT - CT of direct seeded rice has recorded 64%, 62.6% and 16.8% increase of plant height respectively over the zero tillage system at harvest. This increase in plant height might be due to availability of more space, sunlight, nutrients and low weed competition in transplanted rice whereas higher weed density in direct seeded rice and zero tillage rice hindered the uptake of nutrients due to competition which might have resulted in reduced plant height. These results are in accordance with Hussain., *et al.* (2013) [5]. Lowest plant height in unweeded control might be due to weed competition for longer period which inhibited plant growth. Similar results were reported by Hasanuzzaman., *et al.* (2009) [6].

## Effect on Tillers ($m^{-2}$)

Tillering influences production of panicles which contributes higher dry matter production and grain yield. In rice, tillering capacity is mostly influenced by plant density, soil fertility level and reduced competition from weeds. Tiller production was significantly influenced by tillage and weed management practices (Table 2). Higher number of tillers were recorded in transplanted rice over direct seeded rice irrespective of the tillage. Tillage and weed management practices in rice-maize system under conservation agriculture significantly influenced the tiller production in rice. In transplanted rice, CT - CT system recorded higher number of tillers and they were on par with CT - ZT system. In direct seeded rice, CT - CT system produced significantly higher number of tillers over zero tillage direct seeded rice with and without residue cover.

| Treatments | | Tillers (no. $m^{-2}$) | | | |
|---|---|---|---|---|---|
| **Tillage practices** | **Weed management** | **Tillering** | **Panicle initiation** | **Grain filling** | **Harvest** |
| $T_1$- CT (TPR) - CT (maize) | $W_1$ | 472.3 | 556.2 | 477.0 | 428.7 |
| | $W_2$ | 479.6 | 585.0 | 513.3 | 436.0 |
| | $W_3$ | 435.2 | 475.2 | 376.8 | 315.7 |
| $T_2$- CT (TPR) - ZT (maize) | $W_1$ | 469.0 | 550.0 | 461.0 | 421.3 |
| | $W_2$ | 482.3 | 572.3 | 495.0 | 426.7 |
| | $W_3$ | 428.0 | 468.0 | 361.5 | 296.5 |
| $T_3$- CT(DSR) - CT (maize) | $W_1$ | 298.0 | 348.3 | 320.7 | 286.7 |
| | $W_2$ | 302.7 | 355.0 | 332.0 | 305.3 |
| | $W_3$ | 224.3 | 250.0 | 238.3 | 218.7 |
| $T_4$- ZT(DSR) - ZT (maize) | $W_1$ | 276.3 | 298.3 | 226.0 | 196.7 |
| | $W_2$ | 275.0 | 320.0 | 263.3 | 220.0 |
| | $W_3$ | 138.7 | 152.0 | 136.7 | 126.7 |
| $T_5$- ZT+R (DSR)- ZT+R (maize) | $W_1$ | 288.7 | 310.0 | 236.3 | 208.0 |
| | $W_2$ | 293.7 | 325.0 | 274.3 | 244.0 |
| | $W_3$ | 138.0 | 155.0 | 136.7 | 122.0 |
| Mean | | | | | |
| Tillage practices (Main plots) | | | | | |
| $T_1$ - CT (TPR) - CT | | 462.4 | 538.8 | 455.7 | 393.4 |
| $T_2$ - CT (TPR) - ZT | | 459.8 | 530.2 | 439.2 | 381.4 |
| $T_3$ - CT (DSR) - CT | | 275.0 | 317.8 | 297.0 | 270.2 |
| $T_4$ - ZT (DSR) - ZT | | 230.0 | 256.8 | 208.7 | 181.1 |
| $T_5$ - ZT+R (DSR) - ZT+R | | 240.1 | 263.3 | 215.8 | 191.3 |
| Weed management practices (Sub plots) | | | | | |
| $W_1$ - Chemical management | | 360.9 | 412.6 | 344.2 | 308.3 |
| $W_2$ - IWM | | 366.7 | 431.5 | 375.6 | 326.4 |
| $W_3$ - Unweeded control | | 272.9 | 300.1 | 250.0 | 215.9 |

| | SE (m) ± | CD (P =0.05) | SE (m) ± | CD (P =0.05) | SE (m)± | CD (P =0.05) | SE (m) ± | CD (P =0.05) |
|---|---|---|---|---|---|---|---|---|
| Tillage practices (Main plots) | 6.99 | 23.16 | 8.34 | 27.63 | 6.83 | 22.61 | 7.88 | 26.09 |
| Weed management practices | 6.28 | 18.65 | 5.85 | 17.38 | 5.87 | 17.45 | 6.49 | 19.27 |
| SUB AT MAIN | 12.1 | 42.99 | 14.45 | 40.54 | 11.83 | NS | 13.64 | NS |
| MAIN AT SUB | 13.3 | 41.13 | 13.55 | 42.01 | 12.71 | NS | 14.23 | NS |

**Table 2:** Tillers (no. $m^{-2}$) production in rice as influenced by tillage and weed management practices at different stages under conservation agriculture.

CT: Conventional Tillage; TPR: Transplanted Rice; DSR: Direct Seeded Rice; ZT: Zero Tillage; R: Residue Cove

Data on effect of weed management practices on tiller production revealed that IWM (366.7 $m^{-2}$) and chemical weed management (360.9 $m^{-2}$) produced tillers on par with each other at tillering stage. At panicle initiation stage and grain filling stage, IWM registered significantly superior number of tillers over the others. At harvest stage, IWM and chemical weed management produced tillers comparable to each other. Unweeded control recorded the lowest number of tillers at all the stages. Interaction effect of tillage and weed management practices was significant at tillering and panicle initiation stages. At tillering stage in transplanted rice, highest number of tillers were reported with the adoption of IWM in CT - ZT and it was on par with IWM in CT - CT system, chemical weed management in CT - CT and CT - ZT system. In direct seeded rice, highest number of tillers were recorded under IWM of CT - CT system while the lowest number of tillers were recorded under ZT - ZT system with and without residues in unweeded control. Tiller production in IWM and chemical weed management was found to be on par with each other under all the tillage practices. In direct seeded rice, all tillage systems were on par with each other under chemical weed management and IWM. Similar trend was also observed at panicle initiation stage except under chemical weed management of DSR treatments, CT - CT system was superior to zero tillage DSR. At grain filling and at harvest stages interaction was found to be non-significant. Better availability of space, water and nutrients and appropriate soil conditions might have helped in production of more number of tillers under transplanted conditions over DSR in conventional as well as zero tillage systems. Similar findings were reported by Sidhu., *et al.* (2014) [2] and Singh (2013) [7]. Due to lesser weed competition in IWM might have helped in greater absorption of nutrients by rice resulting in increased production of higher number of tillers. Unweeded control received much competition from the weeds might have resulted in production of lesser number of tillers. These results are in confirmation with the findings of Singh., *et al.* (2016) [8].

## Effect on dry matter production (g $m^{-2}$)

Dry matter production indicates growth and yield of the crop which was also an important plant growth parameter in defining grain harvest index which is ratio of grain yield to total biological yield. Tillage and weed management practices significantly influenced the dry matter production presented in table 3. Transplanted rice recorded significantly higher dry matter production compared to direct seeded rice irrespective of the method of tillage. At tillering stage, transplanted rice under CT - CT system recorded significantly higher dry matter production (407.6 g $m^{-2}$) over rest of the tillage treatments and on par with rice under CT - ZT (398.6 g $m^{-2}$). In direct seeded rice, CT - CT system produced significantly higher dry matter (147.2 g $m^{-2}$) than ZT - ZT system with and without residue cover. Similar trend was observed at panicle initiation, grain filling and harvest stages also.

| Treatments | | Dry matter production (g $m^{-2}$) | | | |
|---|---|---|---|---|---|
| **Tillage practices** | **Weed management** | **Tillering** | **Panicle initiation** | **Grain filling** | **Harvest** |
| $T_1$- CT (TPR) - CT (maize) | $W_1$ | 441.7 | 594.7 | 1224.9 | 1450.3 |
| | $W_2$ | 457.1 | 646.7 | 1265.6 | 1491.0 |
| | $W_3$ | 323.8 | 407.5 | 774.6 | 878.0 |
| $T_2$- CT (TPR) - ZT (maize) | $W_1$ | 432.5 | 575.3 | 1180.7 | 1405.0 |
| | $W_2$ | 447.6 | 612.7 | 1238.4 | 1466.7 |
| | $W_3$ | 315.6 | 400.4 | 757.0 | 862.4 |
| $T_3$- CT (DSR) - CT (maize) | $W_1$ | 178.6 | 324.8 | 436.8 | 476.7 |
| | $W_2$ | 192.3 | 339.3 | 476.5 | 511.0 |
| | $W_3$ | 70.7 | 97.6 | 139.5 | 173.0 |
| $T_4$- ZT (DSR) - ZT (maize) | $W_1$ | 139.5 | 182.1 | 273.1 | 335.3 |
| | $W_2$ | 147.1 | 191.5 | 306.7 | 347.0 |
| | $W_3$ | 64.2 | 71.9 | 91.0 | 98.3 |
| $T_5$- ZT+R (DSR) - ZT+R (maize) | $W_1$ | 150.6 | 206.3 | 297.4 | 360.7 |
| | $W_2$ | 158.5 | 222.2 | 342.6 | 386.7 |
| | $W_3$ | 64.9 | 74.9 | 91.6 | 103.7 |

| Mean | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Tillage practices (Main plots) | | | | | | | | |
| $T_1$ - CT (TPR) - CT | 407.6 | | 549.6 | | 1,088.4 | | 1,273.1 | |
| $T_2$ - CT (TPR) - ZT | 398.6 | | 529.5 | | 1,058.7 | | 1,244.7 | |
| $T_3$ - CT (DSR) - CT | 147.2 | | 253.9 | | 351.0 | | 386.9 | |
| $T_4$ - ZT (DSR) - ZT | 116.9 | | 148.5 | | 223.6 | | 260.2 | |
| $T_5$ - ZT+R (DSR) - ZT+R | 124.7 | | 167.8 | | 243.8 | | 283.7 | |
| Weed management practices (Sub plots) | | | | | | | | |
| $W_1$ - Chemical management | 268.6 | | 376.6 | | 682.6 | | 805.6 | |
| $W_2$ - IWM | 280.5 | | 402.5 | | 725.9 | | 840.5 | |
| $W_3$ - Unweeded control | 167.9 | | 210.5 | | 370.7 | | 423.1 | |
| | SE (m) ± | CD (P =0.05) | SE (m) ± | CD (P =0.05) | SE (m) ± | CD (P =0.05) | SE (m) ± | CD (P =0.05) |
| Tillage practices (Main plots) | 5.95 | 19.72 | 6.40 | 21.20 | 8.99 | 29.76 | 8.85 | 29.31 |
| Weed management practices | 4.44 | 13.20 | 6.91 | 20.54 | 9.46 | 28.09 | 9.26 | 27.49 |
| SUB AT MAIN | 10.31 | NS | 11.09 | 47.01 | 15.56 | 64.35 | 15.33 | 63.00 |
| MAIN AT SUB | 10.06 | NS | 14.15 | 43.03 | 19.46 | 59.23 | 19.08 | 58.07 |

**Table 3:** Dry matter production (g $m^{-2}$) in rice as influenced by tillage and weed management practices at different stages under conservation agriculture.

CT: Conventional Tillage; TPR: Transplanted Rice; DSR: Direct Seeded Rice; ZT: Zero Tillage; R: Residue Cover

Among the weed management practices at tillering stage, highest dry matter production was recorded in IWM involving bispyribac sodium as early PoE *fb* hand weeding (280.5 g m-2) which was comparable with chemical weed management (268.6 g $m^{-2}$). At panicle initiation stage, IWM recorded statistically superior dry matter compared to other treatments followed by chemical weed management. Similar trend was observed at panicle initiation, grain filling and at harvest stages. Unweeded control recorded the lowest dry matter at all the growth stages.

Interaction effect of tillage and weed management practices was found to be significant at panicle initiation, grain filling and harvest stages. At panicle initiation stage, significantly higher dry matter was produced under CT - CT system with IWM (646.7 g $m^{-2}$) which was on par with dry matter produced in CT - ZT system with IWM (612.7 g $m^{-2}$) in transplanted rice. Dry matter accumulation in IWM and chemical weed management was comparable under all the tillage practices except under CT - ZT system of TPR. Statistically on par dry matter production was recorded in both transplanted rice treatments in their respective chemical weed management, IWM and unweeded control. In DSR, CT - CT system recorded significantly higher dry matter than ZT - ZT system in IWM and chemical weed management. At grain filling stage and harvest stage comparatively highest amount of dry matter was produced in transplanted rice under IWM of CT - CT system. Dry matter production in IWM and chemical weed management was on par with each other under all the tillage practices. Comparable dry matter was recorded under CT - CT and CT - ZT of TPR in chemical weed management, IWM and unweeded control. Similarly, ZT - ZT and ZT+R - ZT+R systems produced dry matter comparable to each other in all weed management options. CT - CT system recorded significantly higher dry matter than zero tillage DSR at harvest stage.

Relatively weed free environment and lesser intra crop competition in transplanted rice might have encouraged the higher uptake of nutrients, sunlight, availability of water resulted in more growth, tiller production and accumulation of dry matter compared to direct seeded rice in both tilled and no-tilled soils. These results are

in accordance with the findings of Reddy and Hukkeri (1983) [9]. Higher dry matter production in IWM and chemical weed management might be due to lesser weed competition as they were controlled up to critical periods of weed competition and unweeded control received higher competition from weeds throughout the crop period which reduced uptake of nutrients by crop ultimately resulted in lesser dry matter production in unweeded plots. These results are in agreement with findings of Payman and Singh (2008) [10].

## Conclusion

Transplanted rice CT - CT as well CT - ZT proved to be superior in terms of growth parameters compared to direct seeded rice and resulted in higher plant height, more tillers and high dry matter production. Within direct seeded rice, conventional tillage direct seeded rice was superior over zero tillage direct seeded rice with or without residue cover. Integrated weed management involving application of Bispyribac sodium 10% SC 25 g $ha^{-1}$ as early Post-emergence at 2-3 weed leaf stage followed by hand weeding is recommended in both transplanted as well as direct seeded rice for superior growth than chemical weed management.

There is limited about of herbicides that can be used in both transplanted as well as direct seeded rice systems and can be incorporated in integrated weed management. Various other herbicides need to be included in the Integrated weed management and their effects on the growth and development of rice has to be studied.

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