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# Weed Dynamics as Influenced by Irrigation and Rice Establishment Methods

T. THEERTHANA[1], P. S. FATHIMA[2] AND G. R. DENESH[3]
[1]Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru - 560 065
[2]Department of Agronomy, College of Agriculture, V.C. Farm, Mandya, [3]AICRP on Rice, ZARS, V.C. Farm, Mandya
e-Mail : theerthumuthu@gmail.com

**AUTHORS CONTRIBUTION**

T. THEERTHANA : Conceptualization, investigation, original draft preparatiion, data analysis
P. S. FATHIMA & G. R. DENESH : Conceptualization, supervision, data curation, draft correction

***Corresponding Author***:
T. THEERTHANA
Department of Agronomy, UAS, GKVK, Bengaluru

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**ABSTRACT**

The field experiment was conducted with the objective to study the weed population dynamics as influenced by irrigation management practices and rice establishment methods. The results revealed that, irrigation methods and interaction effects of establishment methods and irrigation management practices failed to create significant impact on weed growth. However, rice establishment methods played a very crucial role in smothering weed population during the different crop growth stages. Mechanical transplanting among the methods of establishment recorded lower grass weed count (2.06 no./0.25 m$^2$) at 30 days after sowing (DAS) and manual transplanting (0.67 no./ 0.25 m$^2$) at 60 DAS. Whereas, broadcasting of sprouted rice recorded significantly higher no. of grasses at both 30 and 60 DAS (11.94 and 4.7867 no./0.25 m$^2$, respectively). Manual and mechanical transplanting recorded no sedge population and statistically lower broadleaved weed count (0.44 and 0.44 no./0.25 m$^2$, respectively) at 30 DAS. Semi dry rice recorded significantly higher sedge population (2.89 and 1.67 no./0.25 m$^2$, respectively) and broadleaved weed population (7.33 and 7.50 no./0.25 m$^2$, respectively) at 30 and 60 DAS. Significantly higher total weed count was found in broadcasting of sprouted rice (19.94 no./0.25 m$^2$) at 30 DAS and semi dry rice (9.89 no./0.25 m$^2$) at 60 DAS. Drum seeded rice method of establishment recorded significantly lower per cent chaffyness (16.23%) AWD with mechanical and manual transplanting recorded significantly higher total nitrogen, phosphorous and potassium uptake.

*Keywords* : Broadleaved weeds, Chaffyness, Establishment methods, Grasses, Sedges, Transplanting

RICE (*Oryza sativa* L.) is being one of the staple food crops in the world and in Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. Rice provides about 700 calories / day / person (Sangeetha and Baskar, 2015). Transplanting is the most dominant and traditional method of establishment in irrigated low land rice. The area under transplanted rice in world is decreasing due to scarcity of water and labour. Manual transplanting requires more number of labors besides involving drudgery and is also very expensive. It takes about 250-300 man hours/ha which is roughly about 25 per cent of the total labor requirement of the crop. Also in transplanting method of establishment, the major operations such as nursery preparation, seedling rising, pulling from nursery, transporting and distribution of seedlings to main field and transplanting operation consumes 30-40 per cent of total cost of cultivation (Rani and Jayakiran, 2003). Besides being laborious, this method of establishment also causes drudgery to womenfolk (Budhar and Tamilselvan, 2002). So, a need has been felt to replace the manual transplanting with scientific, economically feasible and environmentally safe establishment method (Sanjay *et al*., 2006; Farooq *et al.,* 2009; Sharma *et al*., 2005 and Nagarjun & Dhanapal, 2018).

Another major concern in rice production systems is the dwindling trend of availability of water resources. The water use efficiency of rice is much lower than other crops. About 5000 litres of water is required to produce 1 kg of paddy (Bouman, 2009). The effort to increase irrigation efficiency up to 10 per cent can help to bring additional 14 million ha area under irrigation.

The challenges and constraints in rice production vary from environment to environment. Weeds are the major threats that affect the rice yields to the greatest extent (Paul *et al*., 2014). The average yield losses in rice due to weed competition are estimated to vary between 40 and 60 per cent which may go up to 90-98 per cent with uncontrolled weed growth (Chauhan and Johnson, 2011). Our challenge is to develop novel technologies and production systems that allow rice production to be maintained or increased in the face of declining water availability and increasing weed infestation (Sylvestre *et al*., 2018).

## Material and Methods

The field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya, University of Agricultural Sciences, Bangalore under Cauvery command area of Karnataka to study the weed dynamics as influenced by irrigation, weed management and rice establishment methods during *kharif* 2018. The experiment was laid out in a split plot design comprised of three main plot irrigation treatments *viz.,* Continuous flooding, Maintenance of saturation up to panicle initiation (PI) and flooding after PI and Alternate wetting and drying (AWD) and five sub plot rice establishment treatments, *viz.,* Drum seeding, Broadcasting of sprouted rice, Semi-dry rice, Mechanical transplanting and Manual transplanting. The combination of 15 treatments replicated thrice. The paddy variety used was '*MTU 1001*'. The soil type was sandy clay loam with pH of 7.25 having electrical conductivity of 0.105 dS/m. The soil was having moderate organic carbon of 0.67 per cent, available nutrients - 370.04 kg/ha N (Moderate), 872.032 kg/ha P (High) and 287.14 kg/ha K (Moderate). The measured quantity of water to each treatment is given using 'Water meter' connected with PVC pipe.

The weed management was done through application of pre-emergent herbicides such as pendimethalin (30% EC) at 3.33 litre/ha in semi-dry rice, bensulfuron methyl 0.6 per cent + pretilachlor 6 per cent GR at 10 kg/ha in other rice establishment methods.

The major weed flora observed in the experimental site were *Fimbrstylis miliacea*, *Cyperus difformis, Cyperus rotundus* (among sedges), *Echinochloa colona, Eleusine indica, Panicum repens, Panicum tripheron* (among grasses) and *Spilanthes acmella, Mimosa invisa, Commelina diffusa, Portulaca oleraceae , Ludwigia parviflora* and *Eclipta alba* (among broad leaved weeds).

## Results

Species wise weed count at different crop growth stages at 30 and 60DAS are presented in Table 1.

Establishment techniques had significant effect on minimizing the density. Irrigation methods and interactions didn't show any significant effect on individual population of grasses, sedges and broadleaved weeds at 30 and 60 DAS.

### Grasses

Among establishment methods, mechanical transplanting recorded significantly lower no. of grasses at 30 DAS. However, at 60 DAS, manual transplanting recorded significantly lower no. of grasses. Broadcasting of sprouted rice recorded significantly higher no. of grasses at both 30 and 60 DAS.

### Sedges

At 30 DAS, mechanical and manual transplanting recorded no sedge population. However, at 60 DAS broadcasting of sprouted rice didn't record any sedge. Semi dry rice recorded significantly higher sedge population at 30 and 60 DAS.

### Broadleaved Weeds

Mechanical and manual transplanting recorded significantly lower no. of broadleaved weeds at 30 DAS and 60 DAS. However, significantly higher

TABLE 1

Species wise and total weed count at different crop growth stages as influenced by irrigation methods and rice establishment methods

| Treatments | 30 DAS | | | | 60 DAS | | | |
|---|---|---|---|---|---|---|---|---|
| | Sedges (No./ 0.25 m²) | Grasses (No./ 0.25 m²) | Broadleaved Weeds (No./ 0.25 m²) | TotalWeed count # (No./ 0.25 m²) | Sedges (No./ 0.25 m²) | Grasses (No./ 0.25m²) | Broadleaved Weeds (No./ 0.25m²) | Total Weed count # (No./0.25m²) |
| *Main plot* | | | | | | | | |
| $I_1$ | 0.00 (0.00) | 0.40 (5.40) | 0.18 (1.60) | 0.50 (7.17) | 0.08 (0.30) | 0.35 (1.80) | 0.52 (3.13) | 0.72 (5.23) |
| $I_2$ | 0.12 (1.93) | 0.55 (6.77) | 0.32 (2.90) | 0.73 (11.60) | 0.12 (0.70) | 0.51 (3.00) | 0.50 (3.13) | 0.81 (6.83) |
| $I_3$ | 0.12 (1.40) | 0.47 (5.80) | 0.35 (4.63) | 0.66 (11.83) | 0.16 (0.73) | 0.37 (2.07) | 0.48 (2.93) | 0.73 (5.73) |
| S.Em.± | 0.04 | 0.05 | 0.03 | 0.04 | 0.08 | 0.08 | 0.07 | 0.07 |
| LSD (P=0.05) | NS | NS | NS | 0.15 | NS | NS | NS | NS |
| *Sub plot* | | | | | | | | |
| $E_1$ | 0.02 (0.22) | 0.69 (11.00) | 0.22 (1.44) | 0.80 (12.94) | 0.15 (0.83) | 0.59 (3.39) | 0.45 (1.94) | 0.81 (6.17) |
| $E_2$ | 0.13 (2.44) | 0.76 (11.94) | 0.57 (5.56) | 0.97 (19.94) | 0.00 (0.00) | 0.74 (4.78) | 0.58 (3.17) | 0.93 (7.94) |
| $E_3$ | 0.26 (2.89) | 0.31 (2.61) | 0.56 (7.33) | 0.74 (12.83) | 0.34 (1.67) | 0.15 (0.72) | 0.90 (7.50) | 1.01 (9.89) |
| $E_4$ | 0.00 (0.00) | 0.31 (2.06) | 0.03 (0.44) | 0.33 (2.50) | 0.04 (0.11) | 0.39 (1.89) | 0.26 (1.33) | 0.51 (3.33) |
| $E_5$ | 0.00 (0.00) | 0.29 (2.33) | 0.03 (0.44) | 0.31 (2.78) | 0.08 (0.28) | 0.19 (0.67) | 0.33 (1.39) | 0.48 (2.33) |
| S.Em.± | 0.06 | 0.06 | 0.07 | 0.05 | 0.06 | 0.06 | 0.07 | 0.07 |
| LSD (P=0.05) | 0.16 | 0.18 | 0.19 | 0.16 | 0.16 | 0.17 | 0.22 | 0.20 |
| *Interaction* | | | | | | | | |
| S.Em.± | 0.10 | 0.10 | 0.11 | 0.09 | 0.11 | 0.11 | 0.13 | 0.16 |
| LSD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS |

# = Log (x+1) transformed value; NS = Non-Significant; Values inside the parenthesis indicates the original values

broadleaved weed population was found in semi dry method of rice establishment at 30 and 60 DAS.

**Total Weed Count**

At 30 DAS, among irrigation methods, maintaining continuous flooding recorded significantly lower total weed count as compared to maintaining saturation and maintaining AWD. While among methods of establishment, mechanical transplanting recorded lower total weed density followed by manual transplanting. At 60 DAS, among rice establishment methods, manual transplanting recorded lower total weed density followed by mechanical transplanting. However, significantly higher total weed count was found in broadcasting of sprouted rice at 30 DAS and semi dry rice at 60 DAS.

Data clearly indicates that establishment techniques played vital role in smothering total weed population during the crop growth stages. Weed count and their

TABLE 2
Yield parameters as influenced by irrigation management practices and establishment methods in rice

| Treatments | Length of panicles (cm) | Panicle weight (g) | Per cent chaffyness |
|---|---|---|---|
| *Irrigation methods (I)* | | | |
| $I_1$: Continuous flooding | 18.52 | 2.13 | 16.18 |
| $I_2$: Maintenance of saturation up to panicle initiation (PI) followed by flooding after PI | 18.02 | 1.98 | 23.97 |
| $I_3$: Alternate wetting and drying up to PI followed by flooding 5±2cm | 17.20 | 1.94 | 21.92 |
| S.Em.± | 0.14 | 0.02 | 0.31 |
| CD (p= 0.05) | 0.54 | 0.06 | 1.23 |
| *Rice establishment methods (E)* | | | |
| $E_1$: Drum seeded rice | 17.61 | 2.26 | 16.23 |
| $E_2$: Broadcasting of sprouted rice | 18.49 | 2.15 | 17.95 |
| $E_3$: Semi dry rice | 18.06 | 1.75 | 24.09 |
| $E_4$: Mechanical transplanting | 17.35 | 1.84 | 25.45 |
| $E_5$: Manual transplanting | 18.07 | 2.07 | 19.74 |
| S.Em.± | 0.37 | 0.06 | 0.49 |
| CD (p= 0.05) | NS | 0.17 | 1.43 |
| *Interaction* | | | |
| $I_1E_1$ | 17.27 | 2.43 | 10.92 |
| $I_1E_2$ | 18.60 | 2.73 | 11.71 |
| $I_1E_3$ | 19.66 | 1.85 | 16.99 |
| $I_1E_4$ | 18.77 | 1.75 | 24.85 |
| $I_1E_5$ | 18.31 | 1.90 | 16.44 |
| $I_2E_1$ | 17.97 | 2.55 | 23.09 |
| $I_2E_2$ | 19.46 | 2.31 | 14.98 |
| $I_2E_3$ | 17.87 | 1.75 | 26.03 |
| $I_2E_4$ | 17.04 | 1.24 | 26.87 |
| $I_2E_5$ | 17.77 | 2.03 | 26.03 |
| $I_3E_1$ | 17.58 | 1.80 | 14.69 |
| $I_3E_2$ | 17.42 | 1.41 | 27.16 |
| $I_3E_3$ | 16.66 | 1.65 | 29.25 |
| $I_3E_4$ | 16.23 | 2.54 | 24.62 |
| $I_3E_5$ | 18.13 | 2.28 | 13.91 |
| S.Em.± | 0.58 | 0.09 | 0.82 |
| CD (p= 0.05) | NS | 0.29 | 2.48 |

*Note:* NS - Non significant

TABLE 3

Total Nitrogen, Phosphorous and Potassium uptake at harvest as influenced by irrigation management practices and establishment methods in rice

| Treatments | Total N uptake (kg $ha^{-1}$) | Total P uptake (kg $ha^{-1}$) | Total K uptake (kg $ha^{-1}$) |
|---|---|---|---|
| *Irrigation methods (I)* | | | |
| $I_1$: Continuous flooding | 118.36 | 19.79 | 118.53 |
| $I_2$: Maintenance of saturation up to panicle initiation (PI) followed by flooding after PI | 118.02 | 19.88 | 119.19 |
| $I_3$: Alternate wetting and drying up to PI followed by flooding 5±2cm | 120.16 | 20.24 | 120.60 |
| S.Em.± | 1.30 | 0.88 | 1.07 |
| CD (p= 0.05) | NS | NS | NS |
| *Rice establishment methods (E)* | | | |
| $E_1$: Drum seeded rice | 116.40 | 18.64 | 117.41 |
| $E_2$: Broadcasting of sprouted rice | 108.99 | 14.48 | 114.62 |
| $E_3$: Semi dry rice | 119.46 | 20.50 | 119.64 |
| $E_4$: Mechanical transplanting | 125.60 | 23.46 | 124.58 |
| $E_5$: Manual transplanting | 123.79 | 22.76 | 120.96 |
| S.Em.± | 0.56 | 0.55 | 0.54 |
| CD (p= 0.05) | 1.65 | 1.61 | 1.58 |
| *Interaction* | | | |
| $I_1E_1$ | 119.35 | 20.10 | 118.92 |
| $I_1E_2$ | 115.43 | 16.20 | 116.64 |
| $I_1E_3$ | 120.63 | 21.47 | 118.32 |
| $I_1E_4$ | 125.43 | 23.88 | 124.59 |
| $I_1E_5$ | 113.20 | 17.28 | 114.18 |
| $I_2E_1$ | 119.07 | 20.65 | 117.20 |
| $I_2E_2$ | 109.08 | 13.15 | 113.27 |
| $I_2E_3$ | 121.80 | 22.70 | 122.04 |
| $I_2E_4$ | 119.36 | 19.40 | 120.76 |
| $I_2E_5$ | 124.14 | 23.51 | 122.70 |
| $I_3E_1$ | 111.44 | 15.17 | 116.10 |
| $I_3E_2$ | 111.02 | 14.08 | 113.94 |
| $I_3E_3$ | 115.96 | 17.33 | 118.57 |
| $I_3E_4$ | 132.33 | 27.11 | 128.38 |
| $I_3E_5$ | 134.04 | 27.49 | 125.99 |
| S.Em.± | 1.56 | 1.23 | 1.36 |
| CD (p= 0.05) | 2.85 | 2.78 | 2.74 |

*Note:* NS - Non significant

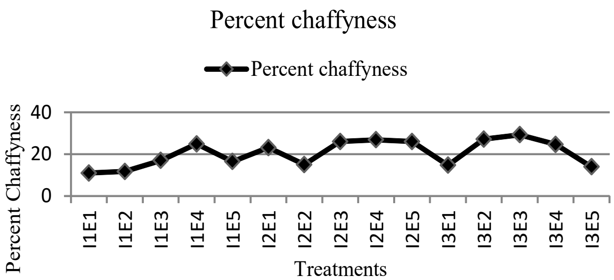



Fig.1: Per cent chaffyness as influenced by irrigation and establishment methods in rice

dominance differed according to the establishment methods. Broadcasting of sprouted rice recorded significantly higher no. of grasses while semi dry rice recorded significantly higher sedge population and broadleaved weed population. Even the total weed count was found highest in these two establishment methods at both 30 and 60 DAS (Ravindranath & Jaidev, 2018; Gill, 2008 and Singh *et al*., 2006).

Whereas, manual and mechanical transplanting recorded statistically lower grasses, sedges and broadleaved weeds and total weed count at 30 and 60 DAS. This may be due to formation of hydrogen peroxides from the an aerobic conditions, which is fatal to the germination of weed seeds (Shantappa, 2014; Singh & Singh, 2003 and Yadav *et al.,* 2009).

Higher weed population in broadcasting of sprouted rice plots might be due to the optimum conditions for weed seed germination. These observations are in agreement with Haefele *et al.* (2004), Shantappa *et al.* (2016) and Arunbabu & Satya *et al*. (2014).

Interaction effects of establishment methods and irrigation management practices failed to create significant impact on weed growth. These results are in line with the findings of Kumar *et al*. (2012); Parameshwari, 2013; Sanjay *et al.,* 2018 and Mandal *et al.* (2013).

**Length of Panicle (cm)**

Length of panicle varied significantly with irrigation methods. Continuous flooding recorded significantly higher length of panicle (18.52 cm) followed by maintenance of saturation up to panicle initiation (PI) followed by flooding after PI (18.02) over alternate wetting and drying up to PI followed by flooding after PI (17.20).

Length of panicle was found non significant among interactions and establishment methods.

**Panicle Weight (g)**

Higher panicle weight (2.13 g) was recorded in continuous flooding method of irrigation, which was significantly superior over rest of the methods (1.94 to 1.98 g).

Drum seeded rice recorded significantly higher panicle weight (2.26 g) followed by broadcasting of sprouted rice (2.15) as compared to remaining establishment methods (1.75 to 2.07 g).

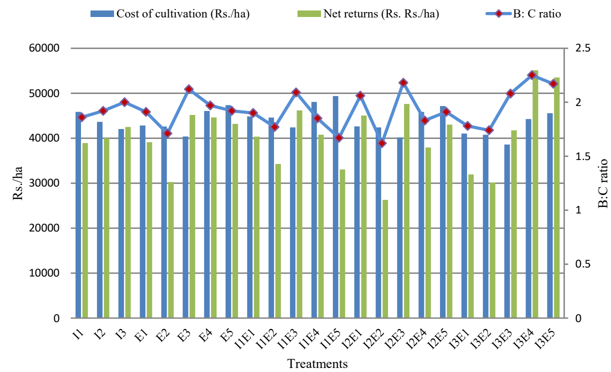
Interaction between continuous flooding and broadcasting of sprouted rice recorded significantly higher panicle weight (2.73 g) followed by maintenance of saturation up to panicle initiation (PI) followed by flooding after PI and drum seeded rice (2.55) and alternate wetting and drying up to PI followed by flooding after PI and mechanical transplanting (2.54) over rest of the interactions (1.24 to 2.43).

**Per cent Chaffyness**

Significantly lower per cent chaffyness was observed in continuous flooding method of irrigation than rest of the methods.

Drum seeded rice method of establishment recorded significantly lower per cent chaffyness over other methods due to the higher number of filled grains per panicle which was favoured by early panicle initiation and grain filling period (Sanjay *et al.,* 2018).

Among interactions, significantly lower per cent chaffyness was recorded in interaction between continuous flooding and drum seeded rice as compared to rest of the interactions. It may be due to the less weed infestation in case of continuous flooding (Shantappa, 2014). Reduction in filled grains has been attributed to decreased anther dehiscence, pollen shedding, pollen viability and pollen germination eventually ending with increased chaffyness




**Irrigation methods (I)**
$I_1$ : Continuous flooding
$I_2$ : Maintenance of saturation up to PI and flooding after PI
$I_3$ : Alternate wetting and drying

**Rice establishment methods (E)**
$E_1$ : Drum seeding
$E_2$ : Broadcasting of sprouted rice
$E_3$ : Semi-dry rice
$E_4$ : Mechanical transplanting
$E_5$ : Manual transplanting

Fig. 2: Economics of rice cultivation as influenced by irrigation management practices and establishment methods

percentage (Sowmyalatha, 2015). Higher per cent chaffyness in alternate wetting and drying might be due to non availability of adequate moisture and nutrients during the grain filling period due to the competition imposed by the weeds (Saharawat *et al.*, 2010).

### Total Nitrogen Uptake (kg ha$^{-1}$)

The total nitrogen uptake in different irrigation methods was non significant. However, alternate wetting and drying up to PI followed by flooding after PI recorded higher total nitrogen uptake at harvest (120.06 kg ha$^{-1}$) compared with rest of the methods (118.02 to 118.36 kg ha$^{-1}$).

Among establishment methods, mechanical transplanting recorded significantly higher total nitrogen uptake (125.60 kg ha$^{-1}$) followed by manual transplanting (123.79 kg ha$^{-1}$). Lower total nitrogen uptake (108.99 kg ha$^{-1}$) was recorded in broadcasting of sprouted rice. This may be due to transplanting of younger seedlings in which the root injury is minimum and presence of more active roots, which resulted in rapid and stable establishment by utilizing more nutrients and moisture for longer period. The results are in conformity with Satyanarayana and Babu (2004).

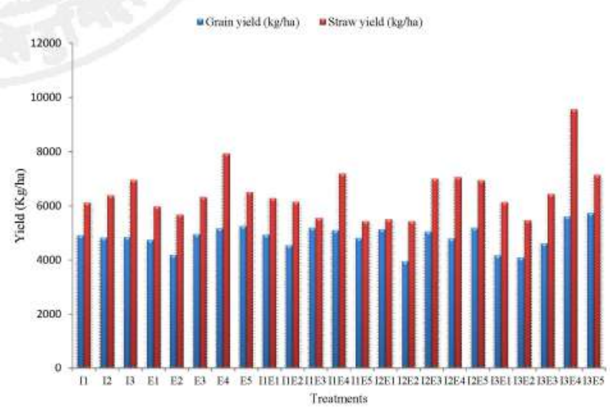
Interaction between alternate wetting and drying up to PI followed by flooding after PI and manual transplanting recorded significantly higher total nitrogen uptake (134.04 kg ha$^{-1}$) which was closely followed by alternate wetting and drying up to PI followed by flooding after PI with mechanical transplanting (132.33 kg ha$^{-1}$) compared to rest of the interactions (109.08 to 125.43 kg ha$^{-1}$).

### Total Phosphorus Uptake (kg ha$^{-1}$)

Total phosphorus uptake was higher in alternate wetting and drying up to PI followed by flooding after PI (20.24 kg ha$^{-1}$) and the effect was non significant when compared to rest of the methods (19.79 to 19.88 kg ha$^{-1}$).

Among establishment methods, mechanical transplanting recorded significantly higher total phosphorus uptake (23.46 kg ha$^{-1}$) followed by manual transplanting (22.76 kg ha$^{-1}$) as compared to rest of the methods (14.48 to 20.50 kg ha$^{-1}$). This may be due to the synchrony between supply and uptake of nutrients through proliferated root system (Chandrapala *et al.*, 2010).

Among interactions, alternate wetting and drying up to PI followed by flooding after PI with manual transplanting recorded significantly higher total phosphorus uptake (27.49 kg ha$^{-1}$) followed by alternate wetting and drying up to PI followed by flooding after PI with mechanical transplanting




**Irrigation methods (I)**
$I_1$ : Continuous flooding
$I_2$ : Maintenance of saturation up to PI and flooding after PI
$I_3$ : Alternate wetting and drying

**Rice establishment methods (E)**
$E_1$ : Drum seeding
$E_2$ : Broadcasting of sprouted rice
$E_3$ : Semi-dry rice
$E_4$ : Mechanical transplanting
$E_5$ : Manual transplanting

Fig. 3 : Rice grain and straw yield as influenced by irrigation management practices and establishment methods in rice

(27.11 kg ha$^{-1}$) as compared to rest of the interactions (13.15 to 23.88 kg ha$^{-1}$).

**Total Potassium Uptake (kg ha$^{-1}$)**

No significant variations were found among irrigation methods with respect to total potassium uptake.

Among establishment methods, mechanical transplanting recorded significantly higher total potassium uptake (124.58 kg ha$^{-1}$) as compared to rest of the methods (114.62 to 120.96 kg ha$^{-1}$). The results obtained are in conformity with the earlier findings of Jayadeva and Prabhakara Shetty (2008) and Satyanarayana and Babu (2004).

Among interactions, AWD with mechanical transplanting recorded significantly higher total potassium uptake (128.38 kg ha$^{-1}$) followed by alternate wetting and drying up to PI followed by flooding after PI with manual transplanting (125.99 kg ha$^{-1}$) over rest of the interactions (113.27 to 124.59 kg ha$^{-1}$).

The study inferred that maintaining continuous flooding method of irrigation with 5 ± 2 cm of standing water reduced the total weed density from initial 30 and 60 DAS. It has also recorded lower percent chaffyness. Rice establishment with transplanting lowered the total weed density of weeds up to 60 DAS as compared to other method of establishment. Further it was observed that, the higher total sedge and broadleaved weed density was recorded from AWD and semi-dry rice, at the same time higher grass weed density was from maintaining saturation and broadcasted rice. AWD with mechanical and manual transplanting recorded significantly higher total nitrogen, phosphorous and potassium uptake.

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