Rice (*oryza sativa* L.) establishment methods and weed management practices influence on weed control and yield under periyar vaigai command area of Tamilnadu, India

Establishment methods and weed management practices in rice

Abstract: Transplanting rice seedlings in un-puddled soils with minimum soil disturbance is an opportunity to expand Conservation Agriculture. Due to delay in onset of monsoon the date of release of water in PVC is highly apocryphal and farmers are in dilemma when to prepare nursery for rice. During pre-maturity stage *Turn system* of water release is implemented which affects yield drastically in PVC command area and availability of labours during peak period. Moreover, direct seeding has emerged as better alternatives over transplanting method. These methods not only result in labour saving, but also result in significant water saving in rice. However, the direct seeding method is confronted with severe weed infestation and yield losses if weeds are not managed well. In order to overcome this difficulty, field experiment was performed at Agricultural College & Research Institute, Tamil Nadu Agricultural University, Madurai, India during *Kharif* season of 2021 and *Rabi* season of 2022 to evaluate the performance of three establishment methods and seven weed management practices on yield and weed control under un-puddled condition. The higher total weed density and total weed dry matter was observed in CTR over DSR and MTR. The maximum rice grain yield was recorded in MTR which was followed by DSR over CTR. Compared with weed management practices, all herbicide treatments and weed free plots recorded lower total weed density and total weed dry matter over unweeded control. Maximum yield reduction due to weeds was observed in unweeded control whereas herbicide applied plots resulted in higher yield. In this study, maximum yield and higher weed control efficiency was noted in MTR method of crop establishment with application of PE Pyrazosulfuron + Pretilachlor 10 kg/ha *fb* EPOE Bispyripac sodium @ 25 g a.i/ha in 2021. Similar trend was noticed in 2022.

Keywords: Weed flora, establishment methods, weed management, herbicides, yield

Introduction

Rice (*Oryza sativa* L.) is the most important staple food in Asia where more than 90 percent of global rice is produced and consumed [1]**.** Over 150 million hectares of rice are planted annually, covering about 10% of the world's arable land. With the world population estimated to increase from 7.8 billion in the year 2020 to about 9.9 billion in the year 2050. It is to be noted that, for almost three decades since the Green Revolution, the rice yield growth rate is approximately 2.5% per year. In Asia, India is the second major producer of rice after China, with the contribution of 21.5% to the world rice production. Rice cultivation methods have been changing from time to time in response to technological developments, water and labor availability, and increased cost of production and higher cropping intensity. Direct seeding and transplanting are two common methods of rice establishment in the world. Direct seeding has been practiced successfully in the past two decades with few manipulations. Several sowing and crop establishment methods have evolved, such as water seeding, dry direct seeding and wet seeding using dry or pre-germinated seeds, and these have offered promise in water scarce and labor shortage scenarios [5,11].In Punjab (India) alone, the area under direct seeded rice has crossed 0.60 mha during 2021. In DSR, 90% yield penalty has been witnessed on account of severe weed competition [6,7]. Transplanting has been the most important and common method of crop establishment under favourable rainfed and irrigated lowland rice in Tropical Asia. Manual transplanting is the most common practice of rice cultivation in South and South East Asia. Generally, rice growers face the problem of skilled labour shortage at the time of transplanting which results into delay transplantation, low plant population and eventually low rice yield [3]. Manual transplanting takes about 300 to 350 man hr ha-1 which is roughly 25 per cent of the total labour requirement of the crop [8]. Urbanisation, migration of labour from agriculture to non-agriculture sector and increased labour costs are seriously threatening the cultivation of crops in general and rice in particular [23]. Non availability of labourers for transplanting at appropriate time leads to delay in transplanting. Delay in transplanting from normal date causes considerable reduction in yield [10,17] which also results in a non-uniform and inadequate seedling populations,. It is essential to reduce the factor by adopting the appropriate transplanting techniques for rice production to control the competitive prices in local and international markets. Mechanization in rice production has its own advantage of time, labour and cost saving with a high yield. The mechanical rice transplanter may experience sinkage and poor wheel traction in puddled soil that decrease its efficiency as other wetland farm machinery. Therefore, un-puddled soil would create more traction and load-bearing capacity compared to puddled soil and thus enhance the efficiency of the mechanical rice transplanter.

Weeds are the most important menace causing low productivity of rice. Experiments showed that yields were comparable across all establishment methods of rice when competition from weeds was removed. Thus, weed control is major prerequisite for improved rice productivity and production in all of the rice establishment methods.Weed infestation in rice has been established as one of the important factors responsible for lower productivity as the weed flora under transplanted conditions cause a yield reduction upto 45 per cent [13]. Weeds compete with rice for moisture, nutrients, light, temperature and space. Furthermore, any delay in weeding which lead to increased weed biomass negatively correlation with yield. Traditionally weed control in rice is done by manual and mechanical means which are most effective and common methods but they are tedious, costly, time consuming and are difficult due to continuous rains during monsoon season. Besides, adequate labour is also not available during critical period of crop weed competition. Application of herbicide mixtures or sequential application of herbicides may be useful for broad-spectrum control of weeds in rice. Due to herbicide resistance, recent herbicide combination is the need of the hour for effective weed management coupled with use low dose high efficiency herbicides so as to reduce the herbicide residue in the soil overall making it easier and economical to the farmer. The present study was taken up to study the effect of different rice establishment techniques and weed management practices on weed control efficiency and yield of rice.

Materials and method

Experimental site

Field experiments were conducted at TamilNadu Agricultural University, Madurai, India during *Kharif* 2021 and *Rabi* 2022 to study the effect of different rice establishment techniques and weed management practices in rice. The experimental field is geographically located in the southern part of TamilNadu (9º54′N, 78º54′E). Soil samples were collected at depth of 15 cm for analysis of nutrient status. Laboratory analysis revealed that the soil of the experimental site had pH of 6.5, low available N (265 kg ha^{-1}), medium P (17 kg ha^{-1}), and available K (224 kg ha^{-1}).

Experimental design

The experiment was laid out in strip plot design with three replications. Treatment consists of three establishment methods in vertical strips and seven weed management practices in horizontal strips. The establishment methods include 1. Drum seeded rice (DSR), 2. Machine transplanted rice (MTR) and 3. Conventional transplanting (CT). Weed management practices include 1. (Pre *fb* Bis) Pretilachlor (0.45 a.i g/ha) applied as pre emergence (PE) at 3 DAS/DAT *fb* Bispyripac sodium (25 g a.i/ha) as early post emergence (EPOE) application at 15 DAS/DAT, 2.(Pyr + Pre *fb* Chl + Met) Pyrazosulfuron + Pretilachlor (10 kg/ha) as pre emergence at 3 DAS/DAT *fb* Chlorimuron ethyl + Metsulfuron methyl (20g/ha) as early post emergence application at 15 DAS/DAT, 3.(Ben + Pre *fb* Chl + Met) Benzsulfuron methyl + Pretilachlor (0.6 kg /ha) as pre emergence at 3 DAS/DAT *fb* Chlorimuron ethyl + Metsulfuron methyl (20g/ha) as early post emergence application at 15 DAS/DAT, 4.(Pyr + Pre *fb* Bis) Pyrazosulfuron + Pretilachlor (10 kg/ha) as pre emergence at 3 DAS/DAT *fb* Bispyripac sodium (25 g a.i/ha) as early post emergence application at 15 DAS/DAT, 5.(Ben + Pre *fb* Bis) Benzsulfuron methyl + Pretilachlor (0.6 kg /ha) as pre emergence at 3 DAS/DAT *fb* Bispyripac sodium (25 g a.i/ha) as early post emergence application at 15 DAS/DAT, 6. (WFC) Weed free check and 7. (UC) unweeded control.

Crop management

Field was prepared by ploughing through reversible mould board which ploughs depth upto two feet. Clods were broken by nine tyne cultivator which is followed by rotavator to make soil fine tilth. Laser levelling was done which saves irrigation water and facilitates field operation, conserves vital resources and increases the yield [16]. Seeds were treated with Azospirillum and soaked for 24 hrs except DSR. Nursery has been prepared by forming seed bed for conventional transplanting and tray nursery for machine transplanting a month before release of water from PVC. After the receipt of water, land was irrigated to level of saturation under unpuddled condition. Seedlings with the age of seventeen days was transplanted (manual and machine) and drum seeding (soaked seeds) was done by drum seeder with oval slot. Basal fertilizer application was done for all treatments at the rate of 150:50:50 kg NPK ha^{-1}

Measurements and observations

Herbicide efficiency on weed density and weed dry matter were evaluated on 15, 30 and 45 DAS/DAT. At each sampling, two quadrats (0.5 × 0.5 m^2) at two locations per plot were placed to estimate weed density and weed dry matter. Weeds observed were uprooted and washed for identifying weed spectrum *viz.*, grasses, sedges and broad leaved weeds and then collected weeds are shade dried and oven dried at 65 ± 5°C for 72 hours which assessed weed dry matter. Weed control efficiency (WCE), Weed index (WI), Weed persistence index (WPI) and Herbicide efficiency index (HEI) were calculated at 15, 30 and 45 DAS/DAT using the formulae,

$$\text{WCE (\%)} = \frac{\text{Wpc - Wpt}}{\text{Wpc}} \times 100$$

Where,

Wpc = Weed density in the control plot

Wpt = Weed density in the treated plot

$$\text{WI} = \frac{\text{X - Y}}{\text{X}} \text{ x } 100$$

Where,

X = Yield from weed free plot

Y = Yield from weeded plot

$$\text{WPI} = \frac{\text{Weed dry weight in treated plot}}{\text{Weed dry weight in control plot}} \times \frac{\text{Weed dry weight in control plot}}{\text{Weed dry weight in treated plot}}$$

Yield observation

The grain yield from each net plot area was harvested separately and threshed manually by beating with sticks, cleaned, weighed at 8 percent moisture level and the final grain yield was expressed in kg ha^{-1}.

Statistical analysis

The data were subjected to statistical analysis using analysis of variance (R Software packages, R version 4.0.3) and means of treatments were compared based on the critical difference (C.D) test at $p < 0.05$. The data on weed density and weed dry matter production were subjected to square root transformation and the transformed values were used in analysis. Correlation of weed density and grain yield determined using R version 4.0.3.

RESULTS

Weed composition, Weed density and Weed dry matter production

Weeds observed in the experimental field during *kharif* 2021 and *Rabi* 2022 were classified under three categories *viz*., Grasses include *Echinochloa colona*, Sedges include *Cyperus iria, Cyperus difformis, Cyperus rotundus* and *Fimbristylis miliaceae*, Broad Leaved Weed (BLW) include *Corchorus olitorius*, *Trianthema portulacastrum*, *Eclipta prostrata, Ammania baccifera*, *Ludwigia octavolis, Cleome viscosa* and *Phyllanthus niruri*. Weed flora were not found in weed free check (WFC) at 15 and 30 DAS/DAT while it was found lower in PE Pyrazosulfuron + Pretilachlor 10 kg/ha *fb* EPOE Bispyripac sodium @ 25 g a.i/ha (Pe + P *fb* B) which is followed by PE Benzsulfuron + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium @ 25 g a.i/ha (Bm + P *fb* B) over unweeded control (UC). BLW were found dominating in unweeded control (UC) than sedges and grasses at 45 DAS/DAT. However, apart from weed free check (WFC) all the weed spectrum were reduced in herbicide applied plots of PE Pyrazosulfuron + Pretilachlor 10 kg/ha *fb* EPOE Bispyripac sodium @ 25 g a.i/ha (Pe + P *fb* B).

Weed density was observed on 15, 30 and 45 DAS/DAT. The total weed density varied significantly ($p \leq 0.05$) in all establishment methods and weed management practices during *kharif* 2021 and *Rabi* 2022 (Table. 1a, 1b, 1c). Among establishment methods, grasses, sedges and BLW were found to be higher under CT and lower in MTR during both the seasons at 15 DAS/DAT (Fig. 1 & 4). Similar trend was found at 30 and 45 DAS/DAT. BLW dominated over grasses and sedges at 30 DAS/DAT during both the seasons which were observed higher in CT compared to MTR and DSR (Fig. 2 & 5). At 45 DAS/DAT, density of all weed flora were observed to be minimum in MTR followed by DSR over CT. Amidst weed management treatments, grasses, sedges and BLW were controlled effectively with Pe + P *fb* B next to weed free check WFC and found higher in UC during both the seasons (Fig. 3 & 6).

Weed dry matter production followed similar trend as weed density. Dry weight of weeds substantially reduced from 15 to 45 DAS/DAT with respect to all establishment methods and weed management practices (Table. 2a, 2b, 2c). At 15, 30 and 45 DAS/DAT, lower dry weight of grasses, sedges and BLW were recorded under MTR. In case of weed management treatments, Pe + P *fb* B noted decreased dry weight next to WFC over UC (Fig. 7-12).

In this study, there was a considerable interaction between establishment methods and weed management practices which exposed lesser weed density and weed dry matter production in MTR followed by DSR among establishment methods and WFC which is followed by herbicide treatment of Pe + P *fb* B over UC across weed management practices .

Weed Control Efficiency, Weed Index, Weed Persistence Index and Herbicide Efficiency Index

Weed control efficiency indicates the magnitude of effective reduction of weed density by weed management treatments over unweeded control. This was highly influenced by different weed management practices. The higher weed control efficiency was registered in WFC (100 %) followed by Pe + P *fb* B (49% to 90%) over other treatments at 15, 30 and 45 DAS/DAT (Table. 3 & 4) during *Kharif* 2021. Similar trend was exposed during *Rabi* 2022 with record of higher weed control efficiency in WFC (100 %) followed by Pe + P *fb* B (60% to 92%) over other treatments at 15, 30 and 45 DAS/DAT (Table. 4 & 5) during *Rabi* 2022.

Mean values of weed persistence index recorded significant difference among establishment methods and weed management practices. Decreased values of WPI were found in Pe + P *fb* B (0.82), (0.89) and (1.57) followed by Bm + P *fb* B (0.84), (1.14) and (1.77) at 15, 30 and 45 DAS/DAT, respectively during *Kharif* 2021 (Table. 3 & 4). Comparably, lower values of WPI were noticed under Pe + P *fb* B (1.00), (1.27) and (1.57) followed by Bm + P *fb* B (1.02), (1.52) and (2.22) at 15, 30 and 45 DAS/DAT, respectively during *Rabi* 2022 (Table. 4 & 5).

Weed index is a measure of yield loss caused due to varying degree of weed competition compared to the relatively weed free condition throughout the crop period leading to higher productivity. Among weed management practices, there was a variability in percent yield reduction. Application of Pe + P *fb* B had yield reduction of 5.5% over other treatments whereas UC recorded higher yield reduction of 47.5% during *Kharif* 2021 while in *Rabi* 2022, yield reduction was found lower in Pe + P *fb* B (4.6%) and greater in UC (51.3%) (Table. 7).

Grain yield and straw yield

Grain yield were significantly ($p \leq 0.05$) influenced by establishment methods and weed management practices during *kharif* 2021 and *Rabi* 2022. The maximum grain yield was recorded under MTR (4874 kg ha^{-1}) which was followed by DSR (4619 kg ha^{-1}) whereas decreased grain yield was found in CT (4156 kg ha^{-1}) across establishment methods. Among weed management practices, higher grain yield was recorded under Pe + P *fb* B (5049 kg ha^{-1}) next to WFC (5332 kg ha^{-1}) compared to UC (2804 kg ha^{-1}) and the yield reduction of CT (14%) and DSR (5%) were observed over MTR among establishment methods. Amidst weed management practices, UC recorded higher percent of yield reduction (47%) over Pe + P *fb* B (5%) and other treatments during *Kharif* 2021. Similar trend was followed in *Rabi* 2022 where among establishment methods, CT had yield reduction of 14% over DSR and MTR. In weed management practices, Pe + P *fb* B had yield reduction of (5%) over UC (51%). The interaction between establishment methods and weed management practices were significant ($p \leq 0.05$) during both the seasons (Table. 6).

Relationship of grain yield with weed density and weed dry matter production

Grain yield revealed significant and negative correlation with weed density and weed dry matter. The coefficient of determination (R^2 $p \leq 0.05$) between the grain yield and weed density were 0.97 and 0.96 at 15 DAS/DAT , 0.88 and 0.92 at 30 DAS/DAT and 0.91 and 0.91at 45 DAS/DAT during *kharif* 2021 and *Rabi* 2022, respectively (Fig. 13 & 14) . The outcome of the regression analysis showed that, the increase of every ten number weeds m^{-2} there was 0.011 kg m^{-2}, 0.0036 kg m^{-2}, 0.0064 kg m^{-2} and 0.013 kg m^{-2}, 0.0074 kg m^{-2}, 0.0041 kg m^{-2} decrease in grain yield of rice during *kharif* 2021 and *Rabi* 2022 at 15, 30 and 45 DAS/DAT, respectively. The coefficient of determination (R^2 $p\leq 0.05$) between the grain yield and weed dry matter were 0.92 and 0.93 at 15 DAS/DAT, R^2 at 30 DAS/DAT were 0.96 and 0.97 and R^2 at 45 DAS/DAT were 0.95 and 0.96 during both the seasons, respectively (Fig. 15 & 16). Regression analysis further reflected that an increase of every 100 g weed dry matter m^{-2} at 15 DAS/DAT reduced the grain yield by 0.035 kg m^{-2}, 0.057 kg m^{-2}, at 30 DAS/DAT 0.012 kg m^{-2}, 0.0047 kg m^{-2} and at 45 DAS/DAT 0.000134 kg m−2, 0.000162 kg m^{-2} during both the seasons, respectively.

DISCUSSION

The present study revealed that there was significant variation in weed composition in all establishment methods and weed management practices at different days after sowing and transplanting during *kharif* 2021 and *Rabi* 2022. Weed composition was found higher in unweeded control. The weed flora consists of grasses include *Echinochloa colona*, sedges include *Cyperus iria*, *Cyperus difformis*, *Cyperus rotundus* and *Fimbristylis miliaceae*, Broad Leaved Weed (BLW) include *Corchorus olitorius*, *Trianthema portulacastrum*, *Eclipta prostrata*, *Ammania baccifera*, *Ludwigia octavolis*, *Cleome viscosa* and *Phyllanthus niruri*. The same results of weed species were in concurrence with findings of authors [12, 18, 22]. Rice establishment methods had significant influence on weed density at 15, 30 and 45 DAS/DAT. Weed density was found to be lower in machine transplanted rice [19]. Among weed management practices lower weed density was recorded under Pyrazosulfuron + Pretilachlor *fb* Bispyripac sodium next to weed free plots. Significant reduction in weed density in low land rice with pyrazosulfuron application was also reported by [2]. Pretilachlor + pyrazosulfuron ethyl (Eros 10 kg ha-1) application also proved more effective in controlling the weeds and reduced their density by 10.25 per cent and 83 per cent compared to commonly used butachlor and weedy check, respectively [4].

Rice establishment methods exerted significant influence on weed dry matter production at 15, 30 and 45 DAS/DAT. Weed dry matter was higher in conventional transplanting [2] and lower in machine transplanted rice followed by drum seeded rice. In case of weed management practices, minimum production of dry matter was observed in Pyrazosulfuron + Pretilachlor *fb* Bispyripac sodium. The same result was proved with [4]. The interaction between establishment methods and weed management practices were found to be significant at 15, 30 and 45 DAS/DAT.

In this study, variable weed control efficiency of herbicides was evident in different methods of establishment in which machine transplanted rice recorded maximum weed control efficiency over drum seeded rice and conventional transplanting. [15] had also reported that the weed control efficiency was higher in mechanical weeding. Higher weed control efficiency was noticed in Pyrazosulfuron + Pretilachlor *fb* Bispyripac sodium followed by Benzsulfuron methyl + Pretilachlor *fb* Bispyripac sodium [4]. Researhers [9] also reported highest weed control efficiency of 78 per cent with the application of pyrazosulfuron in boro rice.

Weed persistence index indicates relative dry matter accumulation of weeds per count in comparison to control. Weed persistence index, which demonstrates the resistance of escaped weed against the particular weed control measure, reflected variability. This variation in WPI values recorded with different weed control treatments at various days after sowing and transplanting (15. 30 and 45). Weed persistence index was found lower in machine transplanted rice among establishment methods and Pyrazosulfuron + Pretilachlor *fb* Bispyripac sodium and Benzsulfuron methyl + Pretilachlor *fb* Bispyripac sodium had better WPI across weed management practices. Yield reduction owing to competition from weeds is represented by weed index. Weed index was lower with machine transplanted rice and application of Pyrazosulfuron + Pretilachlor *fb* Bispyripac sodium which registered lower yield loss. This may be due to increased grain yield obtained in association with increased uptake of nutrients under low weed densities. The results are in line with results of few researchers[14]

Grain yield of rice was influenced by establishment methods. Machine transplanting resulted in significantly higher grain yield compared to DSR and CT. Transplanting by paddy transplanter caused minimum transplanting shocks to seedling and uniform depth of planting resulted in earlier establishment of crop and maximum number of productive tillers resulting in increase in rice yield [20]. Among weed management practices, weed free check and Pyrazosulfuron + Pretilachlor *fb* Bispyripac sodium followed by Benzsulfuron methyl + Pretilachlor *fb* Bispyripac sodium recorded higher grain yield over unweeded control and other herbicide treatments. This was evident from findings of few authors [4].

Conclusion

From the results of two season study, lower weed density and weed dry matter production was noticed under MTR which also produced maximum yield compared to DSR and CT across establishment methods. Amidst weed management practices, pre-emergence application of Pyrazasulfuron plus pretilachlor followed by early-post emergence application of Bispyripac sodium had better weed control efficiency and higher value of weed index when compared to other herbicide treatments and unweeded plot which could be incorporated as better technology by farmers so that they can water and increase yield by minimizing weed infestations.

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Table 1a. Effect of rice establishment methods and weed management practices on weed density at 15 DAS/DAT

	Total weed density (No's m^{-2}) (*Kharif* 2021)									Tota		
	P *fb* B	Pe + P *fb* Ce + Mm	Bm + P *fb* Ce + Mm	Pe + P *fb* B	Bm + P *fb* B	WFC	UC	Mean		P *fb* B	Pe + P *fb* Ce + Mm	Bm + P Ce + M
DSR	64.2 (8.02)*	60.5 (7.82)	67.6 (8.25)	50.7 (7.18)	55.7 (7.51)	1.1 (1.83)	125.2 (11.17)	7.4	**DSR**	72.7 (8.54)	69.0 (8.32)	75.4 (8.69
MTR	52.2 (7.28)	52.8 (7.32)	58.1 (7.67)	41.4 (6.52)	49.6 (7.11)	0.5 (1.48)	115.7 (10.74)	6.8	**MTR**	61.6 (7.86)	61.9 (7.87)	67.7 (8.24
CT	86 (9.28)	76.7 (8.78)	88.8 (9.43)	64.3 (8.06)	67.4 (8.24)	1.1 (1.83)	151.7 (12.28)	8.2	**CT**	91.8 (9.61)	81.5 (9.04)	91.9 (9.60
Mean	8.2	7.9	8.4	7.2	7.6	1.7	11.3		**Mean**	8.6	8.4	8.8
	EM	**WM**	**EM × WM**	**EM × WM**						**EM**	**WM**	**EM × V**
LSD 0.05	0.15	0.87	0.20	0.16					**LSD 0.05**	0.19	0.55	0.62

*Actual figures are transformed to $\sqrt{X+0.5}$ and population figures are given in Paranthesis. EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B - Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 1b. Effect of rice establishment methods and weed management practices on weed density at 30 DAS/DAT

	Total weed density (No's m^{-2}) (*Kharif* 2021)									Total weed density (No's m^{-2}) (*Rabi* 2022)							
	P *fb* B	Pe + P *fb* Ce + Mm	Bm + P *fb* Ce + Mm	Pe + P *fb* B	Bm + P *fb* B	WFC	UC	Mean		P *fb* B	Pe + P *fb* Ce + Mm	Bm + P *fb* Ce + Mm	Pe + P *fb* B	Bm + P *fb* B	WFC	UC	Mean
DSR	29.7 (5.46)	28.5 (5.35)	27.9 (5.39)	24.6 (4.97)	25.9 (5.10)	0.0 (0.72)	174.3 (13.22)	5.7	**DSR**	37.9 (6.17)	36.7 (6.08)	37.2 (6.09)	32.8 (5.74)	34.1 (5.86)	0.0 (0.72)	181.4 (13.48)	6.31
MTR	23.3 (4.82)	25.3 (5.03)	25.1 (5.12)	19.0 (4.35)	21.0 (4.59)	0.0 (0.70)	161.7 (12.7)	5.3	**MTR**	31.5 (5.62)	33.6 (5.80)	33.3 (5.79)	27.2 (5.23)	29.3 (5.42)	0.0 (0.72)	170.9 (13.08)	5.90
CT	34.9 (5.92)	32.0 (5.67)	33.9 (5.84)	27.6 (5.29)	28.3 (5.33)	0.0 (0.70)	198.0 (14.08)	6.1	**CT**	43.1 (6.58)	40.2 (6.36)	42.3 (6.51)	36.1 (6.03)	37.2 (6.1)	0.0 (0.72)	206.8 (14.39)	6.72
Mean	5.4	5.3	5.1	4.8	7.6	0.71	13.34		**Mean**	6.1	6.0	6.2	5.6	5.7	0.72	13.6	
	EM	**WM**	**EM × WM**	**EM × WM**						**EM**	**WM**	**EM × WM**	**EM × WM**				

LSD 0.05	0.11	0.55	0.13	0.90					**LSD 0.05**	0.05	0.24	0.14	0.12				

*Actual figures are transformed to $\sqrt{X+0.5}$ and population figures are given in Paranthesis. EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B - Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 1c. Effect of rice establishment methods and weed management practices on weed density at 45 DAS/DAT

	Total weed density (No's m^{-2}) (*Kharif* 2021)									**Total weed density (No's m^{-2}) (*Rabi* 2022)**							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	21.1 (4.60)	19.7 (4.43)	19.9 (4.46)	16.0 (3.99)	17.3 (4.16)	0.0 (0.70)	205.5 (14.34)	5.24	**DSR**	72.7 (5.21)	69.0 (5.06)	75.4 (5.11)	59.2 (4.70)	64.0 (4.82)	0.0 (0.70)	112.4 (14.61)	5.82
MTR	14.7 (3.81)	16.3 (4.08)	16.9 (4.05)	10.4 (3.17)	12.4 (3.50)	0.0 (0.70)	188.9 (13.76)	4.72	**MTR**	61.6 (4.66)	61.9 (4.93)	67.7 (4.85)	50.9 (4.14)	58.9 (4.39)	0.0 (0.70)	106.4 (13.88)	5.44
CT	26.3 (5.14)	23.4 (4.85)	25.3 (5.04)	19.3 (4.40)	19.7 (4.55)	0.0 (0.70)	240.0 (15.48)	5.83	**CT**	91.8 (5.75)	81.5 (5.48)	91.9 (5.65)	69.5 (5.04)	72.2 (5.12)	0.0 (0.70)	133.0 (15.81)	6.22
Mean	4.52	4.45	4.56	3.85	4.03	0.70	14.53		**Mean**	5.21	5.15	5.20	4.63	4.77	0.70	14.77	
	EM	**WM**	**EM × WM**	**EM × WM**						**EM**	**WM**	**EM × WM**	**EM × WM**				
LSD 0.05	0.18	0.56	0.29	0.32					**LSD 0.05**	0.28	0.58	0.41	0.38				

*Actual figures are transformed to $\sqrt{X+0.5}$ and population figures are given in Paranthesis. EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B - Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 2a. Effect of rice establishment methods and weed management practices on weed dry matter production (DMP) at 15 DAS/DAT

	Total weed DMP (g m^{-2}) (*Kharif* 2021)									**Total weed DMP (g m^{-2}) (*Rabi* 2022)**							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb***	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce +**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**

				B								Mm					
DSR	26.1 (5.14)	23.2 (4.86)	28.7 (5.40)	17.5 (4.23)	19.4 (4.45)	0.0 (0.70)	42.5 (6.53)	4.52	**DSR**	33.8 (5.84)	30.9 (5.59)	36.4 (6.07)	25.3 (5.06)	27.1 (5.24)	0.0 (0.70)	50.0 (7.10)	5.25
MTR	18.7 (4.37)	18.3 (4.33)	20.3 (4.55)	12.8 (3.64)	14.6 (3.87)	0.0 (0.70)	38.1 (6.20)	3.98	**MTR**	26.4 (5.18)	26 (5.14)	28.0 (5.33)	20.5 (4.57)	22.3 (4.76)	0.0 (0.70)	45.8 (6.80)	4.80
CT	34.2 (5.89)	34.8 (5.93)	35.2 (5.97)	24.9 (5.03)	26.8 (5.22)	0.0 (0.70)	48.8 (7.02)	5.14	**CT**	42.0 (6.51)	42.6 (6.55)	42.9 (6.58)	32.6 (5.74)	34.5 (5.91)	0.0 (0.70)	56.5 (7.55)	5.82
Mean	5.13	5.04	5.30	4.30	4.51	0.70	6.58		**Mean**	5.84	5.76	5.99	5.12	5.30	0.70	7.15	
	EM	**WM**	**EM × WM**	**EM × WM**						**EM**	**WM**	**EM × WM**	**EM × WM**				
LSD 0.05	0.01	0.15	0.17	0.19					**LSD 0.05**	0.06	0.25	0.08	0.12				

*Actual figures are transformed to $\sqrt{X+0.5}$ and population figures are given in Paranthesis. EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B - Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 2b. Effect of rice establishment methods and weed management practices on weed dry matter production (DMP) at 30 DAS/DAT

	Total weed DMP (g m^{-2}) (*Kharif* 2021)									**Total weed DMP (g m^{-2}) (*Rabi* 2022)**							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	15.5 (3.98)	12.6 (3.61)	18.1 (4.31)	7.0 (2.70)	8.8 (3.03)	0.0 (0.70)	55.8 (7.50)	4.48	**DSR**	23.6 (4.89)	20.7 (4.59)	26.2 (5.16)	15.0 (3.92)	16.9 (4.15)	0.0 (0.70)	74.7 (8.66)	4.58
MTR	8.1 (2.92)	7.7 (2.85)	9.7 (3.18)	2.2 (1.61)	4.0 (2.10)	0.0 (0.70)	48.7 (7.01)	3.69	**MTR**	16.2 (4.08)	15.8 (4.02)	17.6 (4.27)	10.3 (3.27)	12.1 (3.54)	0.0 (0.70)	62.8 (7.95)	3.97
CT	23.7 (4.91)	24.3 (4.97)	24.6 (5.01)	14.3 (3.84)	16.2 (4.08)	0.0 (0.70)	61.4 (7.86)	2.91	**CT**	31.7 (5.67)	32.3 (5.72)	32.7 (5.75)	22.4 (4.77)	24.3 (4.97)	0.0 (0.70)	83.0 (9.12)	5.24
Mean	3.94	3.81	4.17	2.71	3.07	0.70	7.46		**Mean**	4.88	4.78	5.06	3.99	4.22	0.70	8.58	
	EM	**WM**	**EM × WM**	**EM × WM**						**EM**	**WM**	**EM × WM**	**EM × WM**				
LSD 0.05	0.11	0.26	0.18	0.16					**LSD 0.05**	0.10	0.29	0.16	0.19				

*Actual figures are transformed to $\sqrt{X+0.5}$ and population figures are given in Paranthesis. EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B - Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 2c. Effect of rice establishment methods and weed management practices on weed dry matter production (DMP) at 45 DAS/DAT

	Total weed DMP (g m^{-2}) (*Kharif* 2021)									Total weed DMP (g m^{-2}) (*Rabi* 2022)							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	9.2 (3.08)	6.3 (2.57)	11.8 (3.49)	3.1 (1.88)	3.6 (2.02)	0.0 (0.70)	73.8 (8.61)	3.20	**DSR**	14.9 (3.91)	12.0 (3.53)	17.5 (4.24)	6.3 (2.60)	8.2 (2.93)	0.0 (0.70)	83.4 (9.15)	3.87
MTR	3.6 (2.03)	2.9 (1.83)	4.8 (2.31)	1.7 (1.51)	2.8 (1.79)	0.0 (0.70)	65.1 (8.09)	2.63	**MTR**	7.5 (2.82)	7.7 (2.81)	9.4 (3.14)	2.5 (3.27)	4.2 (3.54)	0.0 (0.70)	69.5 (8.36)	3.10
CT	17.3 (4.21)	17.9 (4.27)	18.3 (4.32)	8.6 (3.01)	10.4 (3.29)	0.0 (0.70)	84.0 (9.18)	4.14	**CT**	23.0 (4.85)	23.6 (4.90)	24.1 (4.94)	13.7 (1.69)	15.6 (2.15)	0.0 (0.70)	91.9 (9.61)	4.68
Mean	3.11	2.89	3.38	2.13	2.37	0.70	8.63		**Mean**	3.85	3.75	4.11	2.68	3.03	0.70	9.04	
	EM	**WM**	**EM × WM**	**EM × WM**						**EM**	**WM**	**EM × WM**	**EM × WM**				
LSD 0.05	0.14	0.23	0.26	0.23					**LSD 0.05**	0.15	0.24	0.20	0.22				

*Actual figures are transformed to √ X+0.5 ~~and~~ and population figures are given in Paranthesis. EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B - Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 3. Effect of rice establishment methods and weed management practices on weed control effiecincy (WCE) and weed persistence index (WPI)

	Weed control efficiency (WCE) (15 DAS/DAT- *Kharif 2021*)									Weed persistence index (15 DAS/DAT- *Kharif 2021*)							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	35.33	38.56	32.90	47.35	43.01	100.00	-	49.52	**DSR**	0.95	0.89	1.01	0.79	0.81	-	-	0.89
MTR	42.09	41.84	36.35	52.18	44.59	100.00	-	52.84	**MTR**	0.85	0.83	0.84	0.70	0.69	-	-	0.78
CT	30.96	38.71	30.91	47.73	45.70	100.00	-	49.00	**CT**	1.02	1.16	1.04	0.97	1.01	-	-	1.04

Mean	36.12	39.70	33.38	49.08	44.43	100.00	-		**Mean**	0.94	0.96	0.97	0.82	0.84	-	-	
	Weed control efficiency (WCE) (30 DAS/DAT- *Kharif 2021*)									**Weed persistence index (30 DAS/DAT- *Kharif 2021*)**							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	72.99	79.77	76.85	83.47	81.22	99.83	-	82.36	**DSR**	1.22	1.01	1.48	0.87	1.12	-	-	1.14
MTR	81.58	80.39	80.51	84.10	82.91	100.00	-	84.92	**MTR**	1.02	0.90	1.04	0.74	1.10	-	-	0.96
CT	79.16	80.54	79.64	82.56	81.62	100.00	-	83.94	**CT**	2.41	1.44	2.04	1.05	1.21	-	-	1.63
Mean	77.91	80.23	79.01	83.38	81.92	99.94	-		**Mean**	1.55	1.12	1.52	0.89	1.14	-	-	

EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B - Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 4. Effect of rice establishment methods and weed management practices on weed control effiecincy (WCE) and weed persistence index (WPI)

	Weed control efficiency (WCE) (45 DAS/DAT- *Kharif 2021*)									**Weed persistence index (45 DAS/DAT- *Kharif 2021*)**							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	83.11	88.07	84.99	89.68	87.80	99.28	-	88.82	**DSR**	1.96	1.72	2.28	1.39	1.72	-	-	1.81
MTR	88.77	87.42	87.85	93.25	90.01	100.00	-	91.22	**MTR**	1.66	1.40	1.63	1.73	1.89	-	-	1.66
CT	79.20	88.09	80.00	88.40	86.80	100.00	-	87.08	**CT**	2.42	2.36	2.08	1.58	1.69	-	-	2.03
Mean	83.69	87.86	84.28	90.44	88.20	99.76	-		**Mean**	2.01	1.83	2.00	1.57	1.77	-	-	
	Weed control efficiency (WCE) (15 DAS/DAT- *Rabi 2022*)									**Weed persistence index (15 DAS/DAT- *Rabi 2022*)**							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	48.72	51.68	46.03	59.48	55.53	100.00	-	60.24	**DSR**	1.13	1.07	1.19	0.97	0.99	-	-	1.07
MTR	54.89	54.32	49.76	64.18	57.08	100.00	-	63.37	**MTR**	1.03	1.01	1.05	0.88	0.87	-	-	0.97
CT	43.33	49.45	41.48	57.60	55.59	100.00	-	57.91	**CT**	1.20	1.34	1.22	1.15	1.20	-	-	1.22
Mean	48.98	51.82	45.76	60.42	56.07	100.00			**Mean**	1.12	1.14	1.15	1.00	1.02	-	-	

EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B **-** Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 5. Effect of rice establishment methods and weed management practices on weed control effiecincy (WCE) and weed persistence index (WPI)

	Weed control efficiency (WCE) (30 DAS/DAT- *Rabi* 2022)									**Weed persistence index (30 DAS/DAT- *Rabi* 2022)**							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	77.63	82.79	81.07	85.91	83.37	100.00	-	85.13	**DSR**	1.60	1.39	1.86	1.25	1.50	-	-	1.52
MTR	85.61	83.92	82.06	88.27	87.01	100.00	-	87.81	**MTR**	1.41	1.28	1.43	1.12	1.48	-	-	1.34
CT	78.79	83.82	82.32	85.93	84.85	100.00	-	85.95	**CT**	2.79	1.82	2.42	1.44	1.59	-	-	2.01
Mean	80.68	83.51	81.82	86.70	85.08	100.00			**Mean**	1.93	1.50	1.90	1.27	1.52	-	-	
	Weed control efficiency (WCE) (45 DAS/DAT- *Rabi* 2022)									**Weed persistence index (45 DAS/DAT- *Rabi* 2022)**							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	84.91	90.43	87.35	92.23	91.60	100.00	-	91.09	**DSR**	2.42	2.18	2.74	1.85	2.18	-	-	2.27
MTR	92.23	91.16	90.47	95.61	93.43	100.00	-	93.82	**MTR**	2.12	1.86	2.09	2.19	2.34	-	-	2.12
CT	79.58	90.24	83.75	90.00	87.50	100.00	-	88.51	**CT**	2.88	2.82	2.56	2.04	2.15	-	-	2.49
Mean	85.57	90.61	87.19	92.61	90.84	100.00	-		**Mean**	2.47	2.29	2.46	2.03	2.22	-	-	

EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B **-** Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 6. Effect of rice establishment methods and weed management practices on grain yield

	Grain yield (kg ha^{-1}) (*Kharif* 2021)									**Grain yield (kg ha^{-1}) (*Rabi* 2022)**							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**		**P *fb* B**	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**

DSR	4657	4817	3722	5067	4909	5366	2857	4619	**DSR**	4458	4605	4578	4815	4754	5052	2589	4407
MTR	4829	5027	4948	5420	5153	5648	3103	4874	**MTR**	4802	4973	4887	5159	5097	5369	2957	4749
CT	4201	4500	4661	4659	4574	4982	2453	4156	**CT**	4109	4355	3706	4632	4549	4980	1977	4044
Mean	4558	4781	4434	5049	4878	5332	2804		**Mean**	4456	4644	4391	4869	4800	5134	2508	
	EM	**WM**	**EM × WM**	**EM × WM**						**EM**	**WM**	**EM × WM**	**EM × WM**				
LSD 0.05	62.87	111.15	158.57	155.30					**LSD 0.05**	58.19	66.53	135.77	132.01				

*Actual figures are transformed to $\sqrt{X+0.5}$ and population figures are given in Paranthesis. EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B **-** Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

Table 7. Effect of rice establishment methods and weed management practices on weed index (WI)

	Weed index (WI) *Kharif 2021*							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	12.82	10.37	11.58	5.38	8.22	-	46.67	15.84
MTR	13.29	10.29	11.41	4.11	7.58	-	44.56	15.21
CT	16.32	10.81	25.66	7.00	8.27	-	51.52	19.93
Mean	14.14	10.49	16.22	5.50	8.02	-	47.58	
	Weed index (WI) *Rabi 2022*							
	P *fb* B	**Pe + P *fb* Ce + Mm**	**Bm + P *fb* Ce + Mm**	**Pe + P *fb* B**	**Bm + P *fb* B**	**WFC**	**UC**	**Mean**
DSR	13.33	9.59	10.64	5.06	7.31	-	49.34	13.61
MTR	11.13	7.05	8.88	3.01	4.75	-	45.14	11.42
CT	17.29	12.21	26.02	5.96	7.72	-	59.66	18.41
Mean	13.92	9.62	15.18	4.68	6.59	-	51.38	

EM- Establishment methods; WM- Weed management; DSR- Drum seeded rice, MTR- Machine transplanted rice, CT- Conventional transplanting; P *fb* B **-** Pretilachlor *fb* Bispyripac sodium, Pe + P *fb* Ce + Mm- Pyrazosulfuron + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Bm + P *fb* Ce + Mm- Benzsulfuron methyl + Pretilachlor *fb* Chlorimuron ethyl + Metsulfuron methyl, Pe + P *fb* B- Pyrazosulfuron + Pretilachlor *fb* EPOE Bispyripac sodium, Bm + P *fb* B – Benzsulfuron methyl + Pretilachlor @ 0.6 kg/ha *fb* EPOE Bispyripac sodium, WFC- Weed free check, UC- Unweeded control.

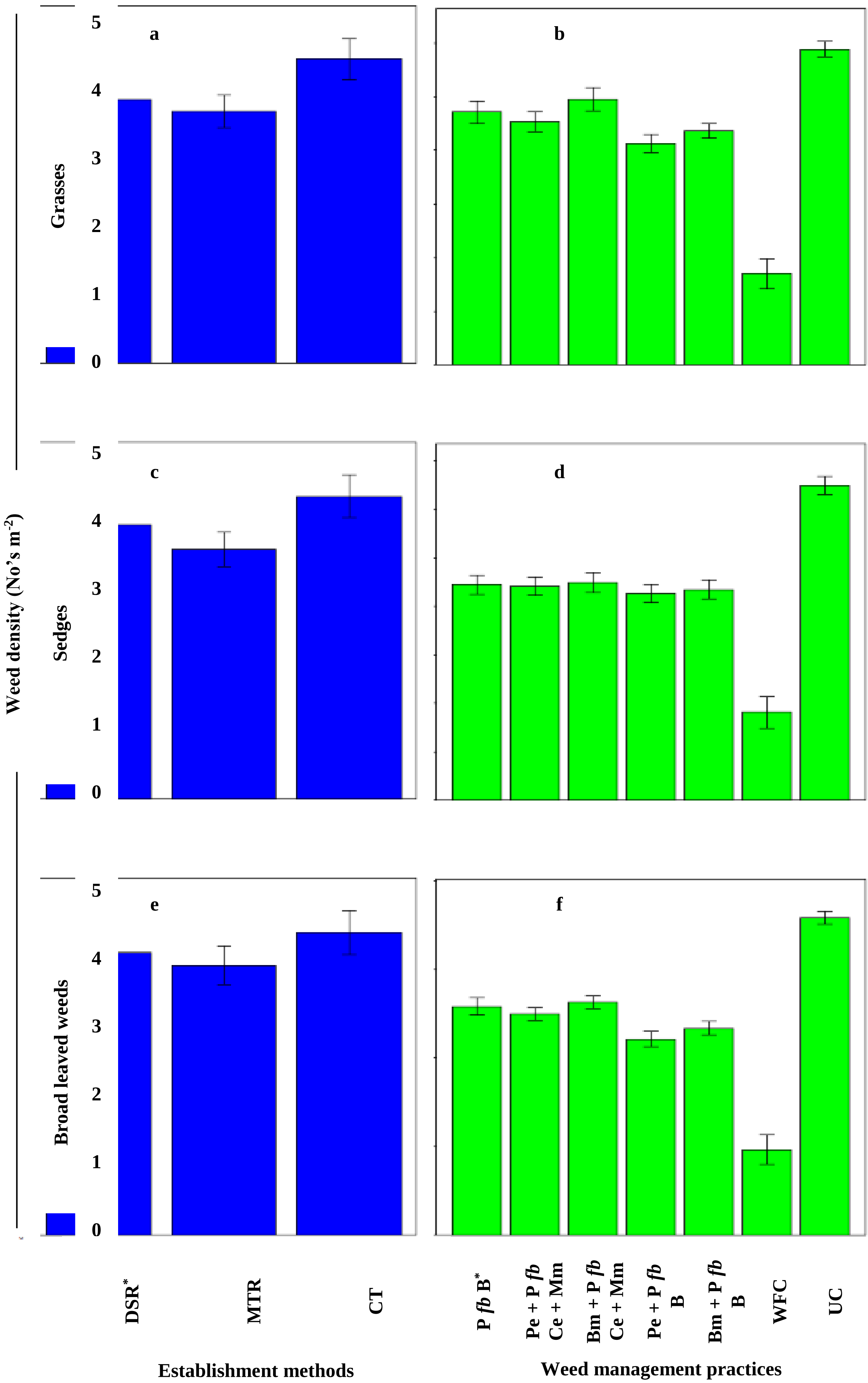


Figure 1. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed density at 15 DAS/DAT during *Kharif* 2021. * Refer to materials and methods for establishment methods and weed management practices.

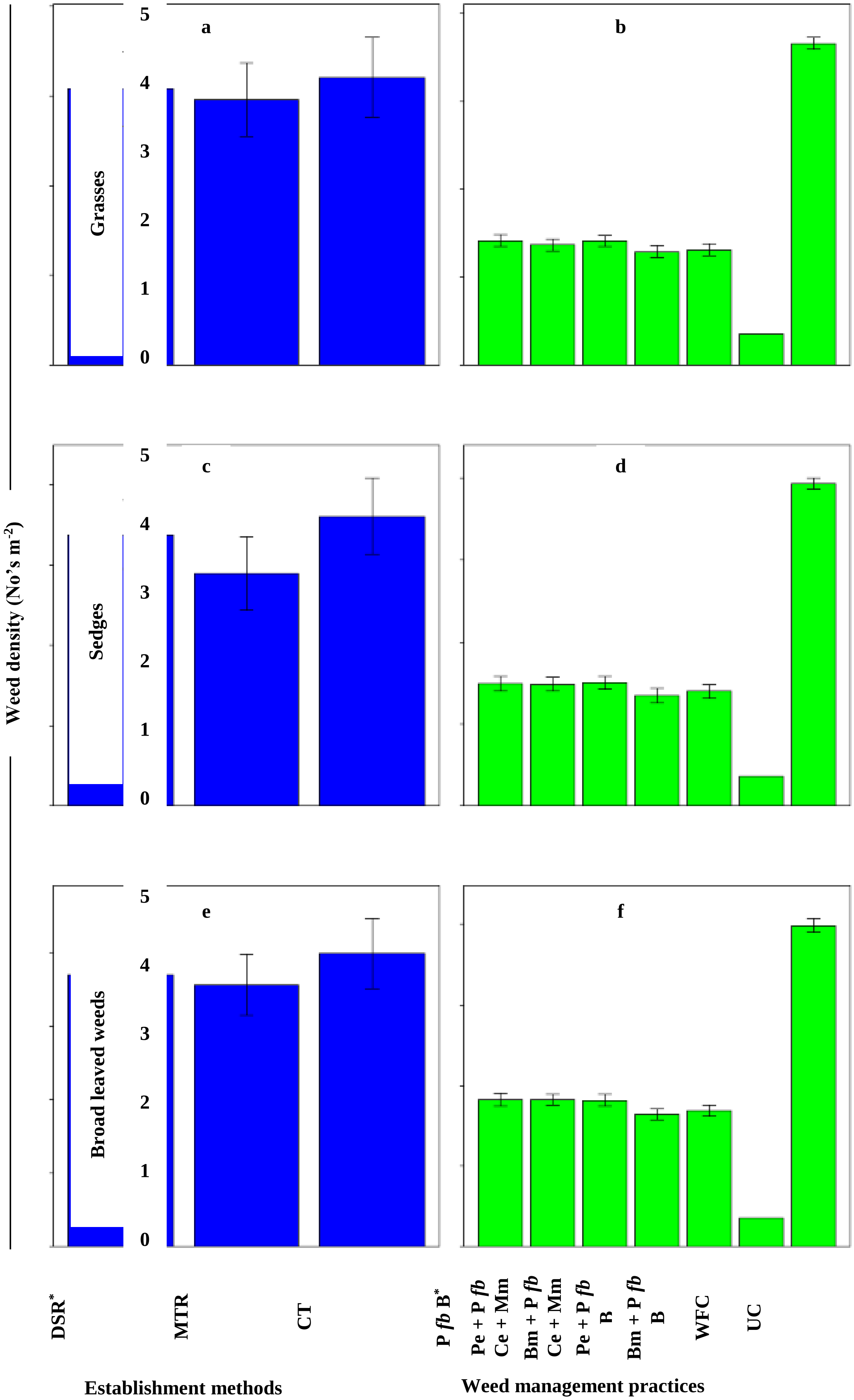


Figure 2. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed density at 30 DAS/DAT during *Kharif* 2021. * Refer to materials and methods for establishment methods and weed management practices.

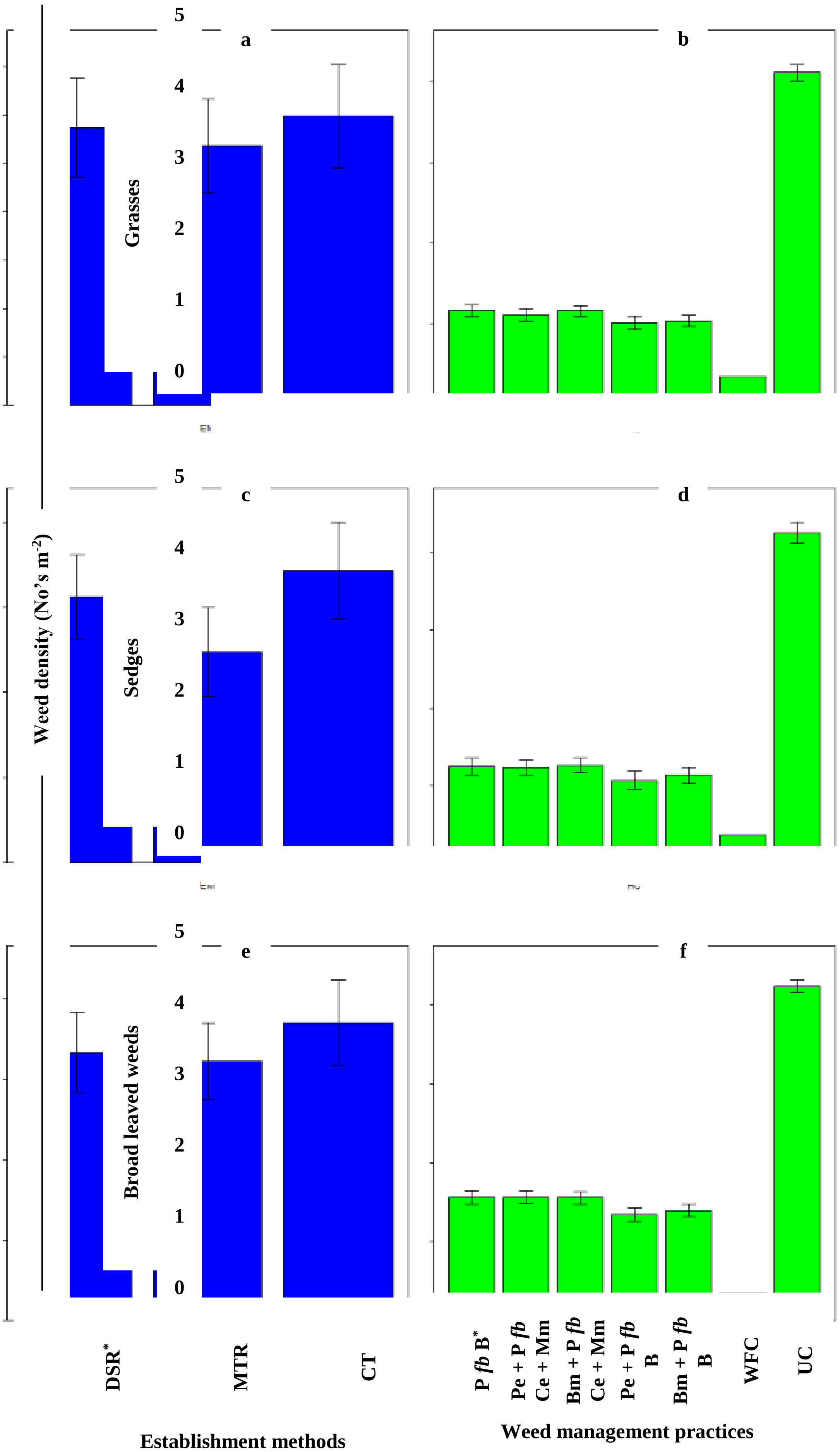


Figure 3. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed density at 45 DAS/DAT during *Kharif* 2021. * Refer to materials and methods for establishment methods and weed management practices.

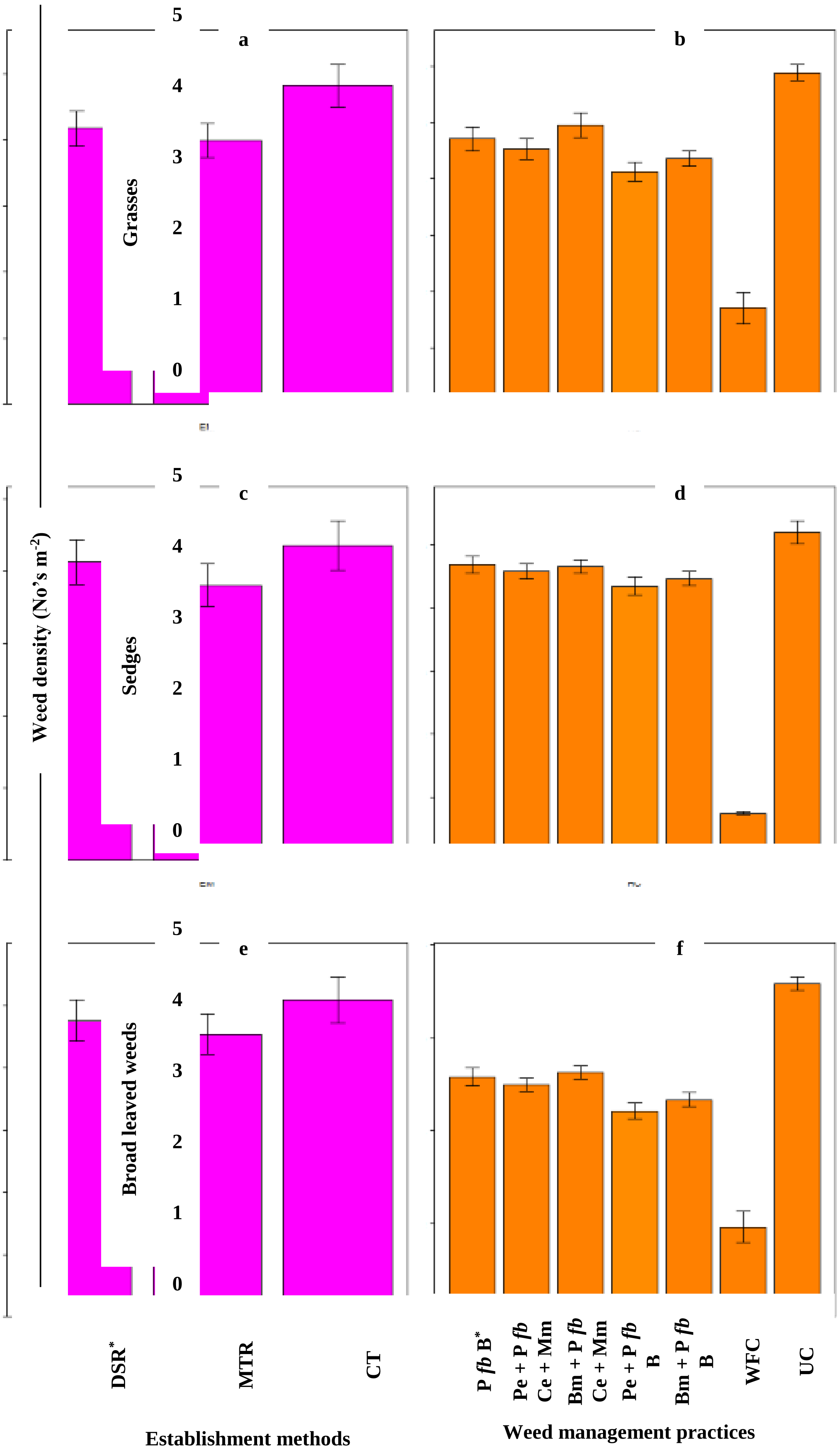


Figure 4. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed density at 15 DAS/DAT during *Rabi* 2022. * Refer to materials and methods for establishment methods and weed management practices.

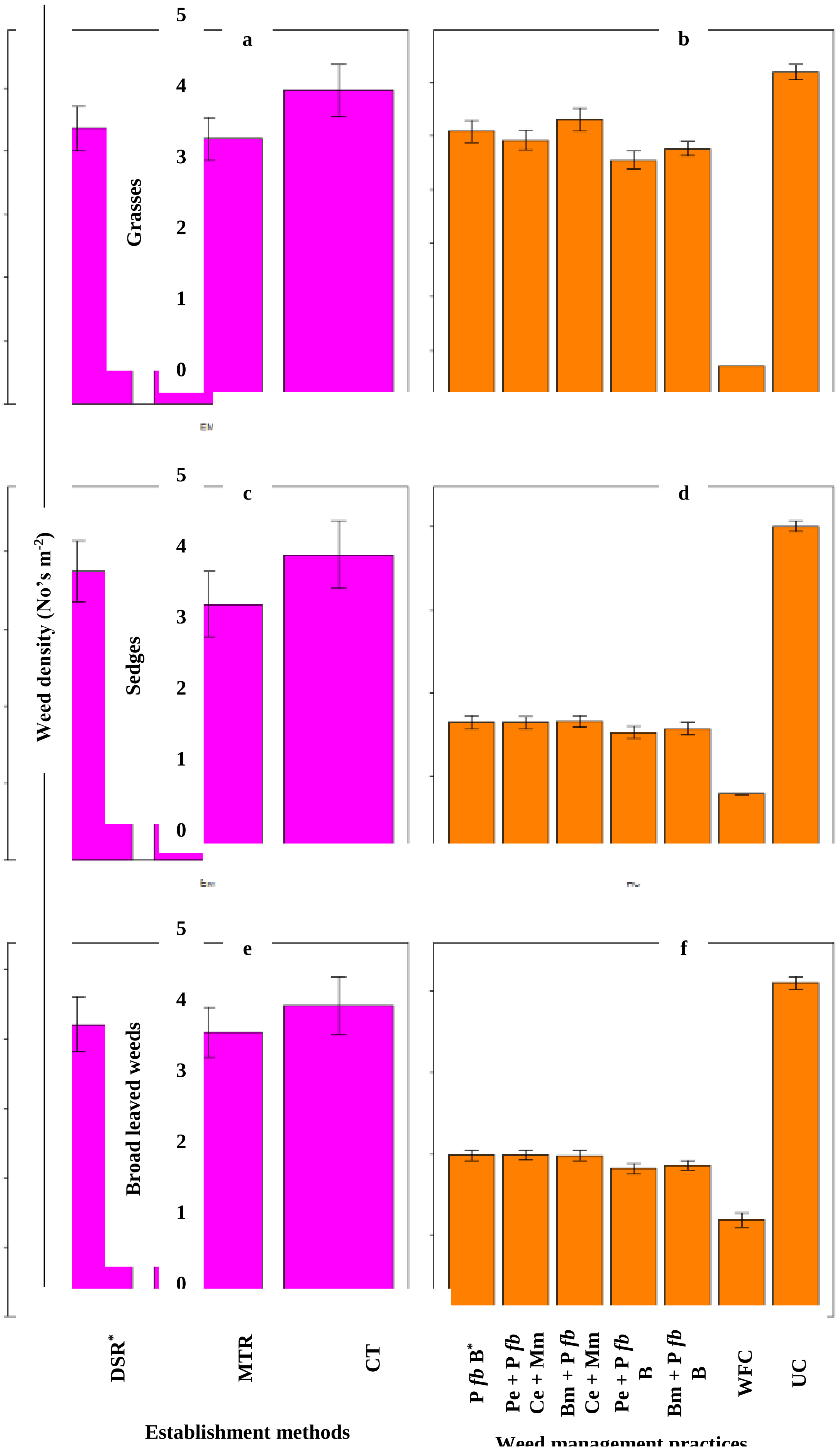


Figure 5. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed density at 30 DAS/DAT during *Rabi* 2022. * Refer to materials and methods for establishment methods and weed management practices.

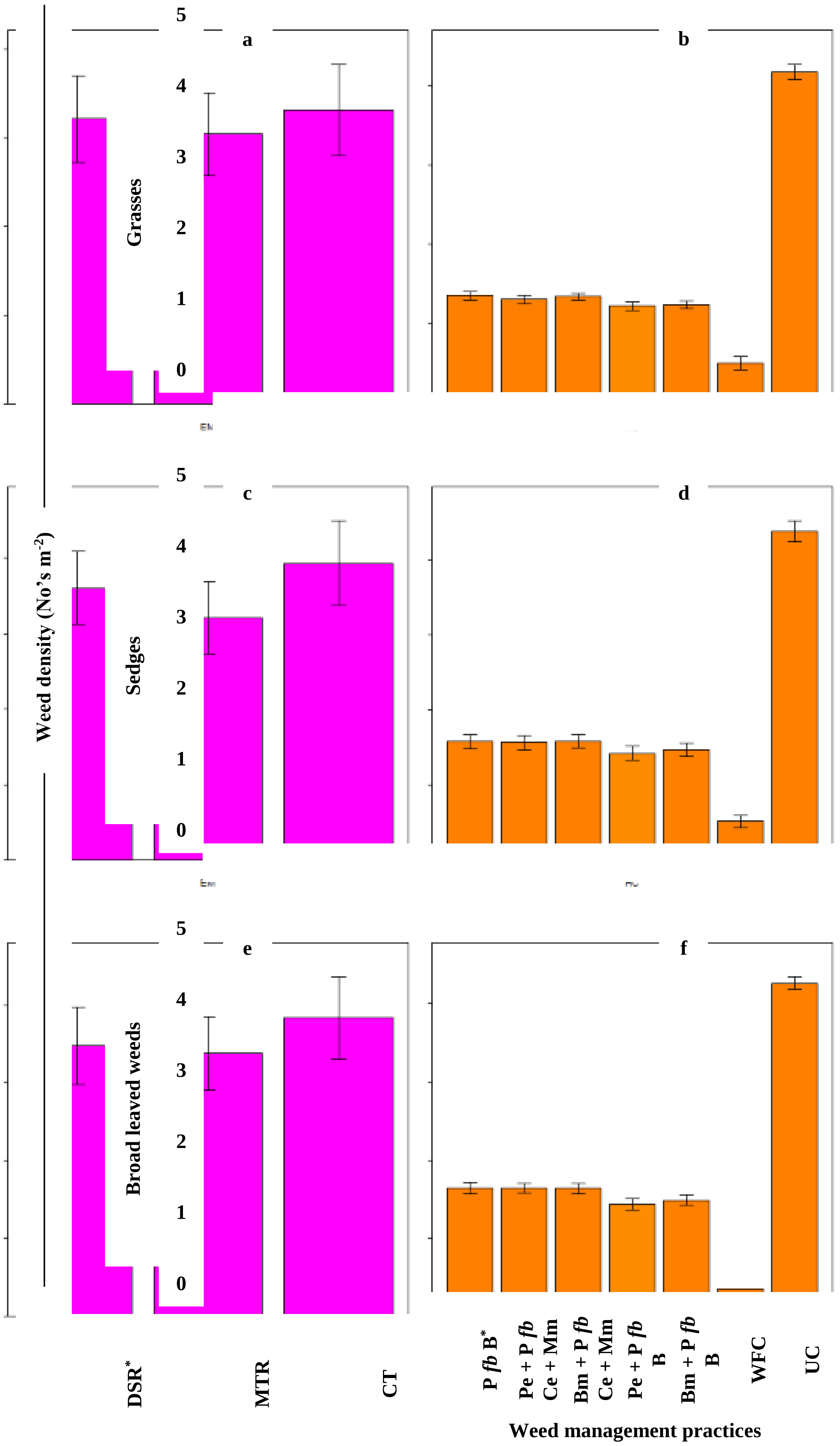


Figure 6. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed density at 45 DAS/DAT during *Rabi* 2022. * Refer to materials and methods for establishment methods and weed management practices.

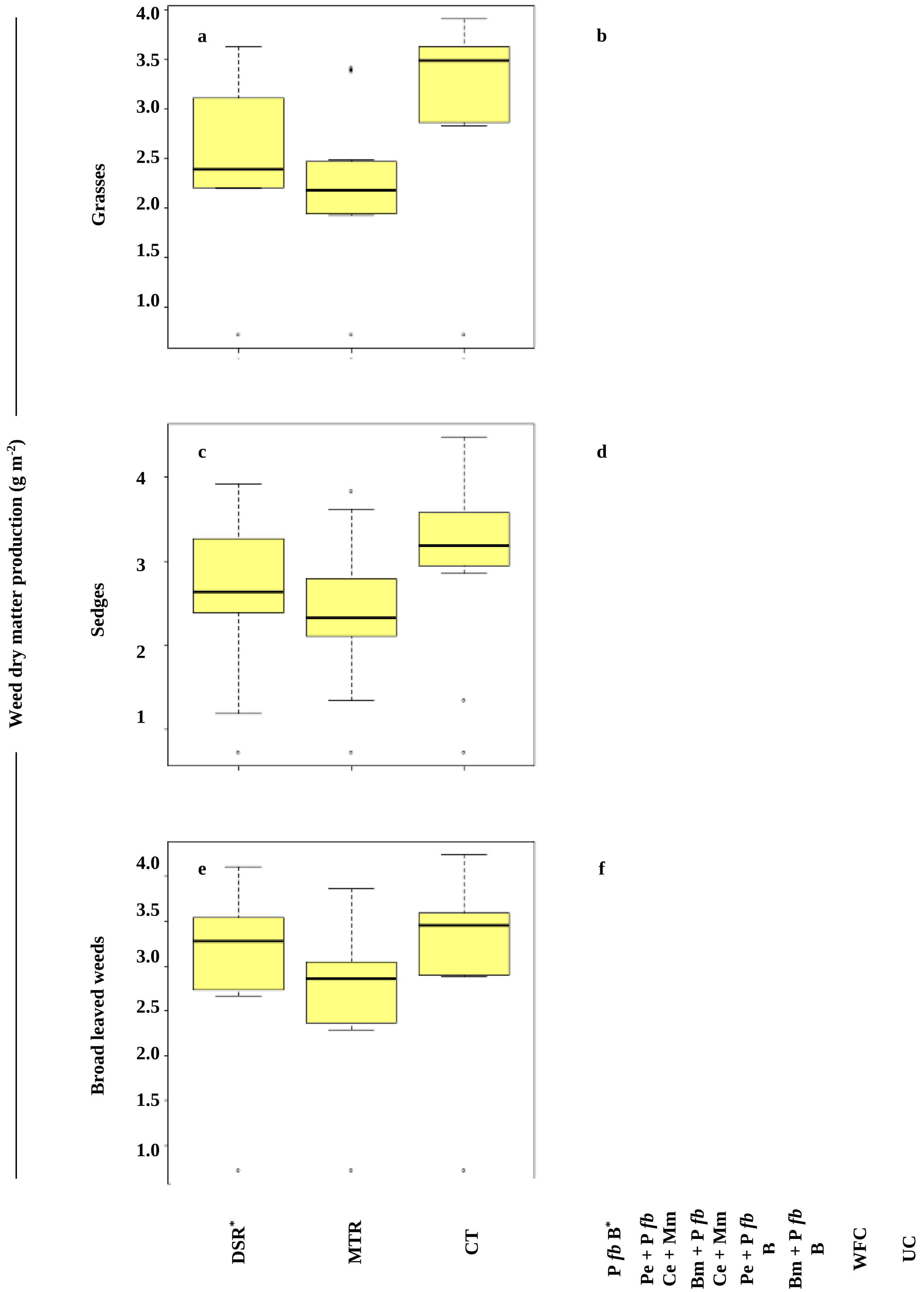
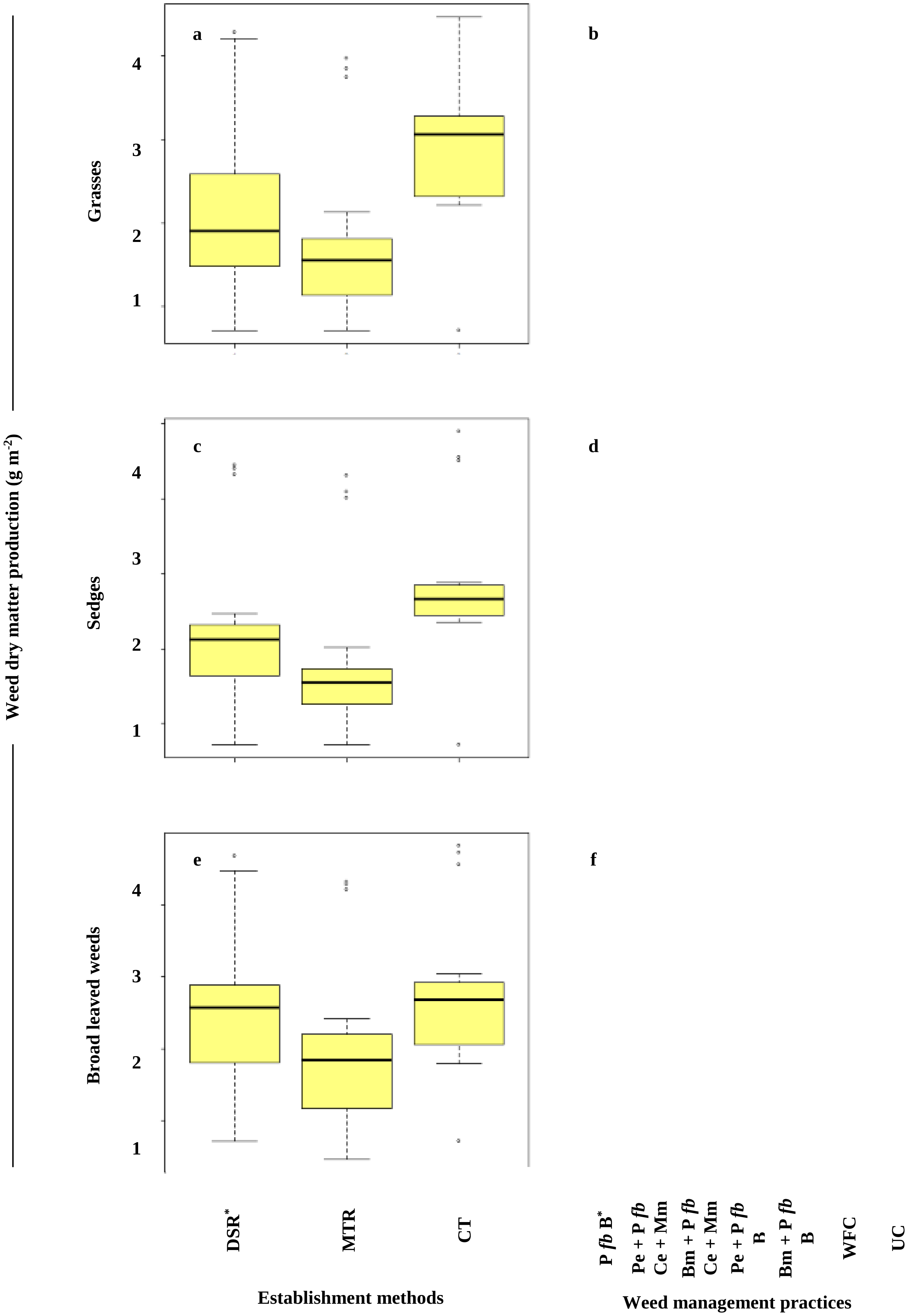


Figure 7. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed DMP at 15 DAS/DAT during *Kharif* 2021. * Refer to materials and methods for establishment methods and weed management practices.


a
b
c
d
e
f
Weed dry matter production (g m-2)
Grasses
Sedges
Broad leaved weeds
1
2
3
4
DSR*
MTR
CT
Establishment methods
P fb B*
Pe + P fb
Ce + Mm
Bm + P fb
Ce + Mm
Pe + P fb
B
Bm + P fb
B
WFC
UC
Weed management practices

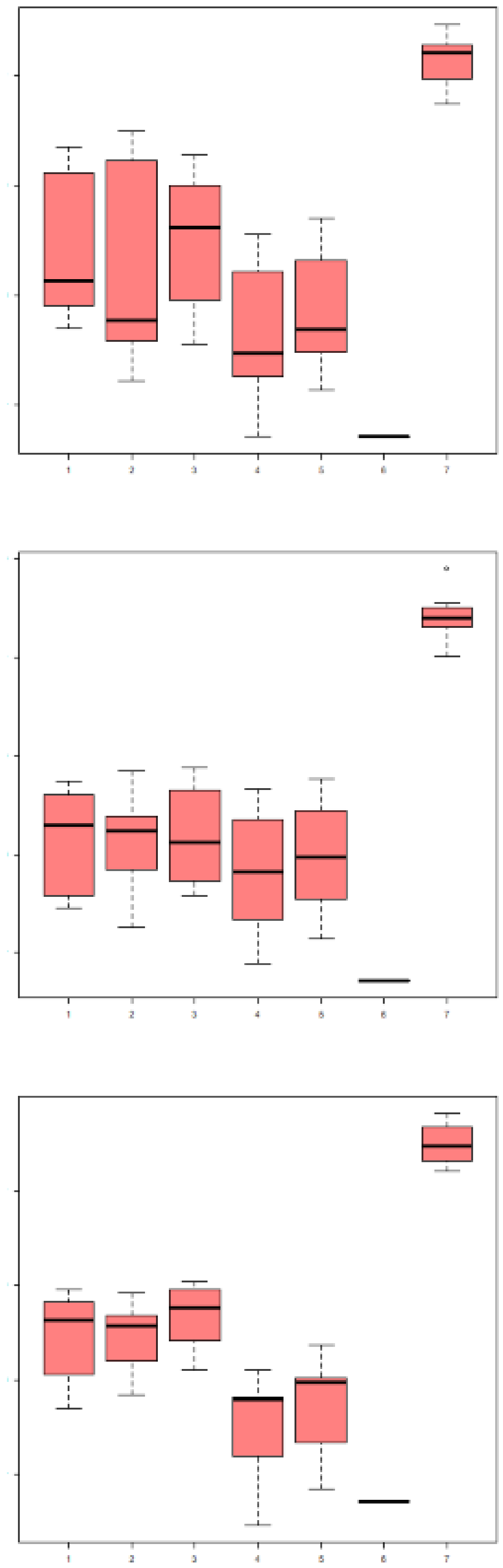
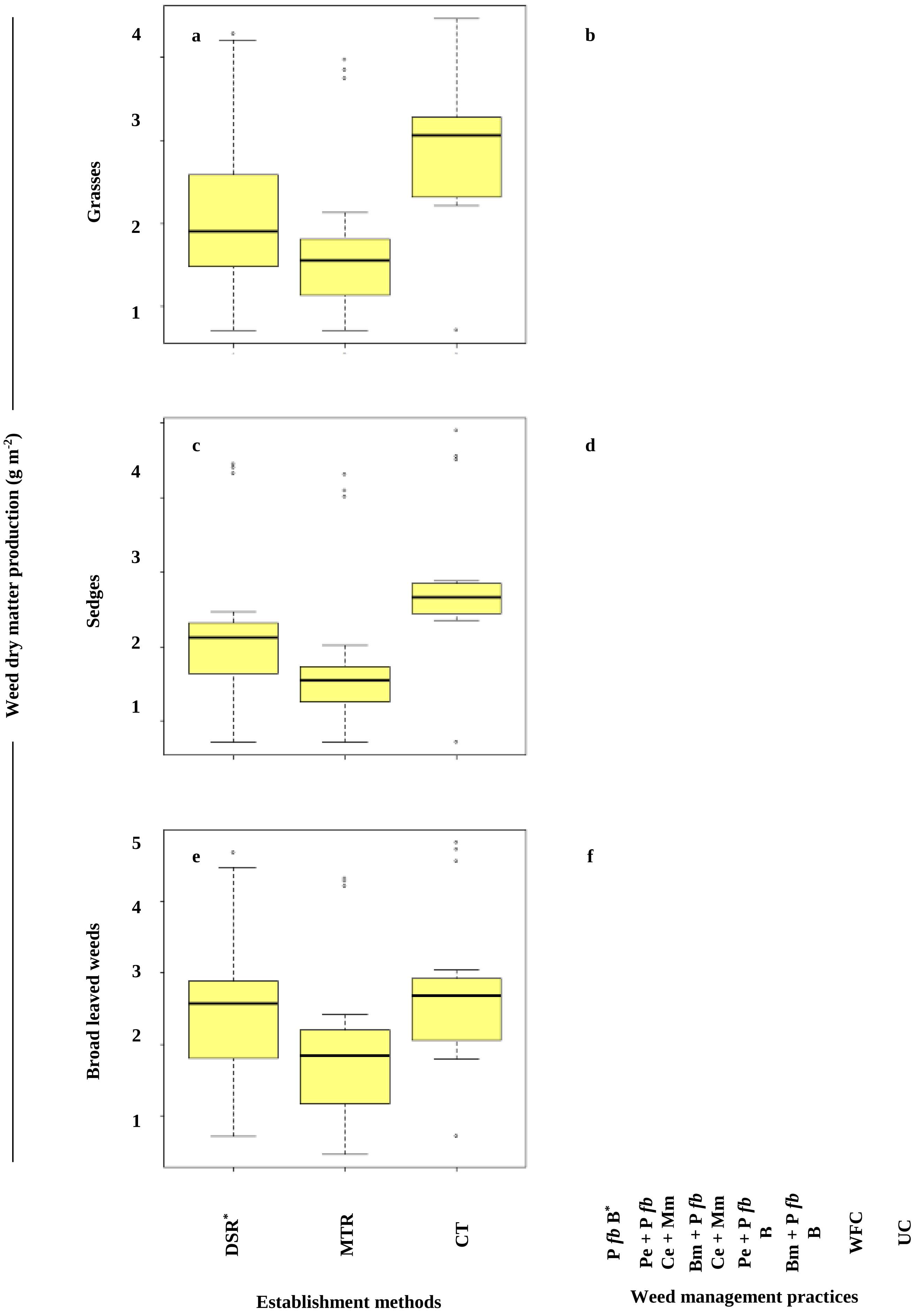


Figure 8. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed DMP at 30 DAS/DAT during *Kharif* 2021. * Refer to materials and methods for establishment methods and weed management practices.


Weed dry matter production (g m-2)
Grasses
Sedges
Broad leaved weeds
a
b
c
d
e
f
1
2
3
4
5
DSR*
MTR
CT
Establishment methods
P fb B*
Pe + P fb
Ce + Mm
Bm + P fb
Ce + Mm
Pe + P fb
R
Bm + P fb
B
WFC
UC
Weed management practices

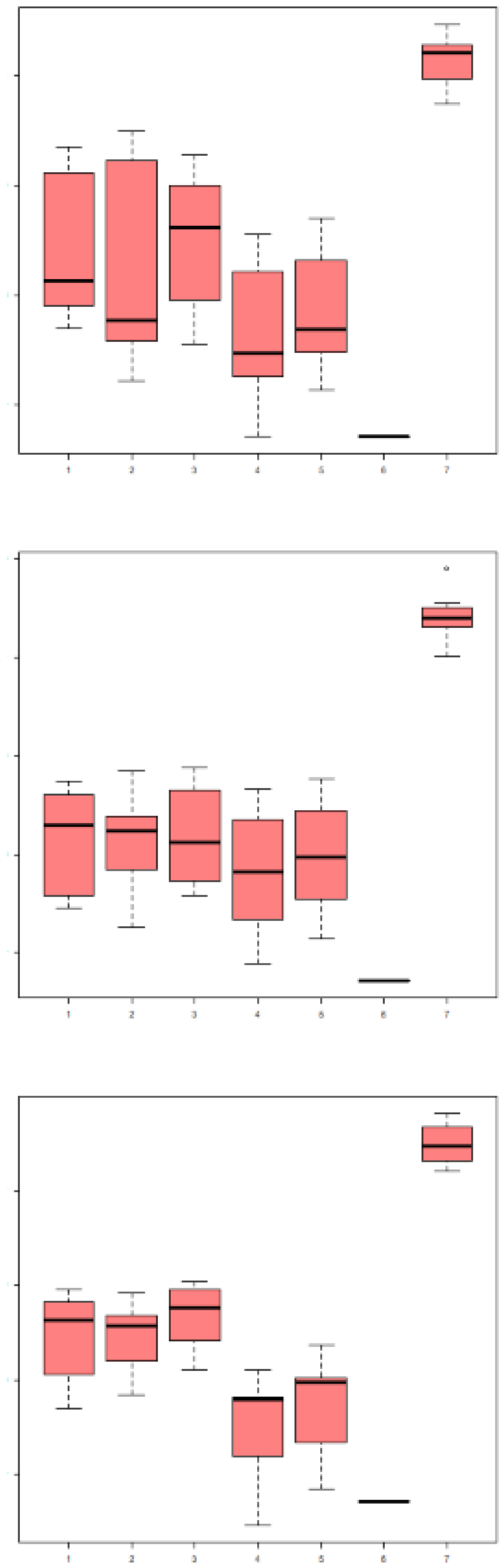
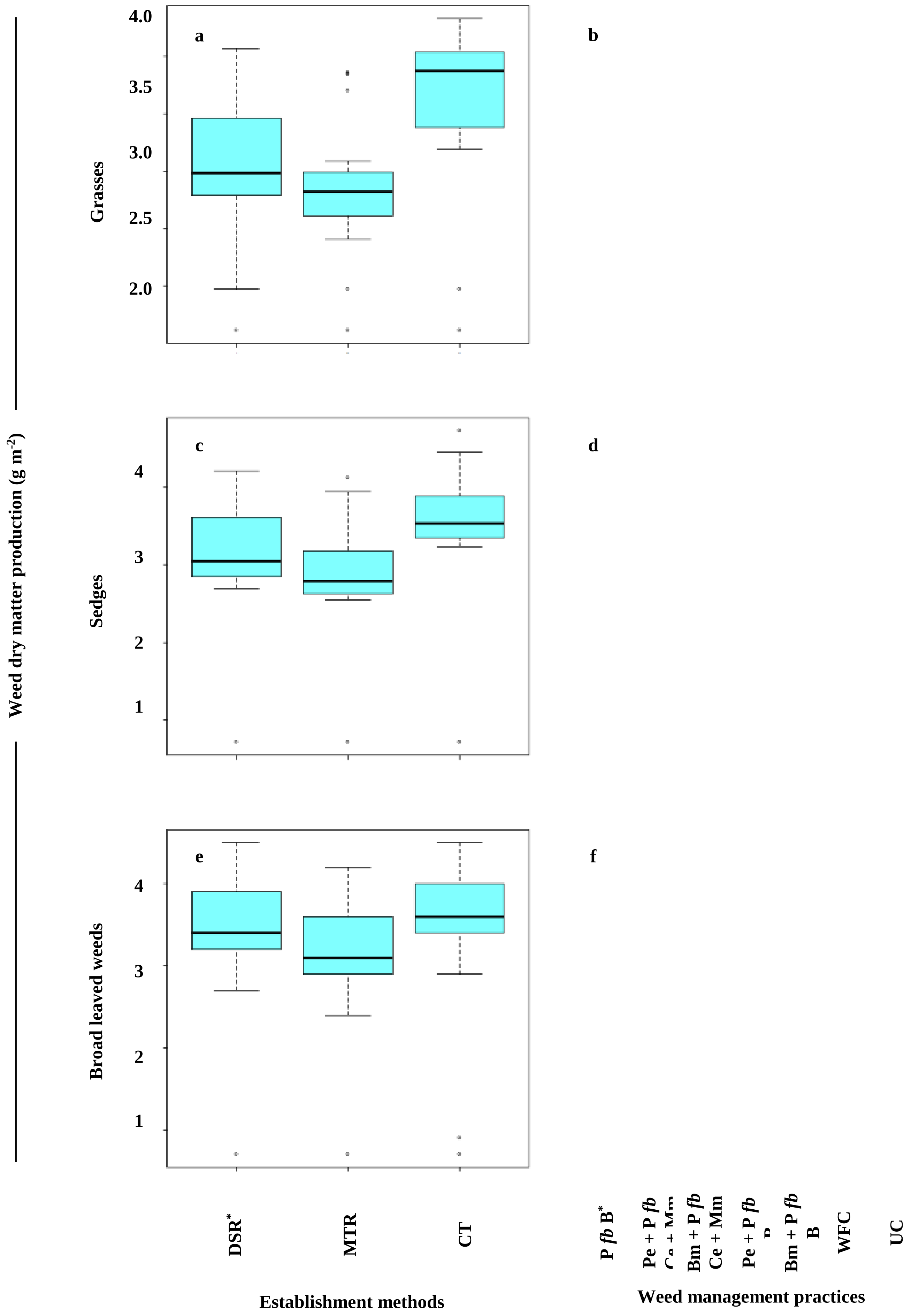


Figure 9. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed DMP at 45 DAS/DAT during *kharif* 2021. * Refer to materials and methods for establishment methods and weed management practices.


Weed dry matter production (g m-2)
Grasses
Sedges
Broad leaved weeds
a
b
c
d
e
f
4.0
3.5
3.0
2.5
2.0
4
3
2
1
DSR*
MTR
CT
Establishment methods
P fb B*
Pe + P fb
Bm + P fb
Ce + Mm
Pe + P fb
Bm + P fb
B
WFC
UC
Weed management practices

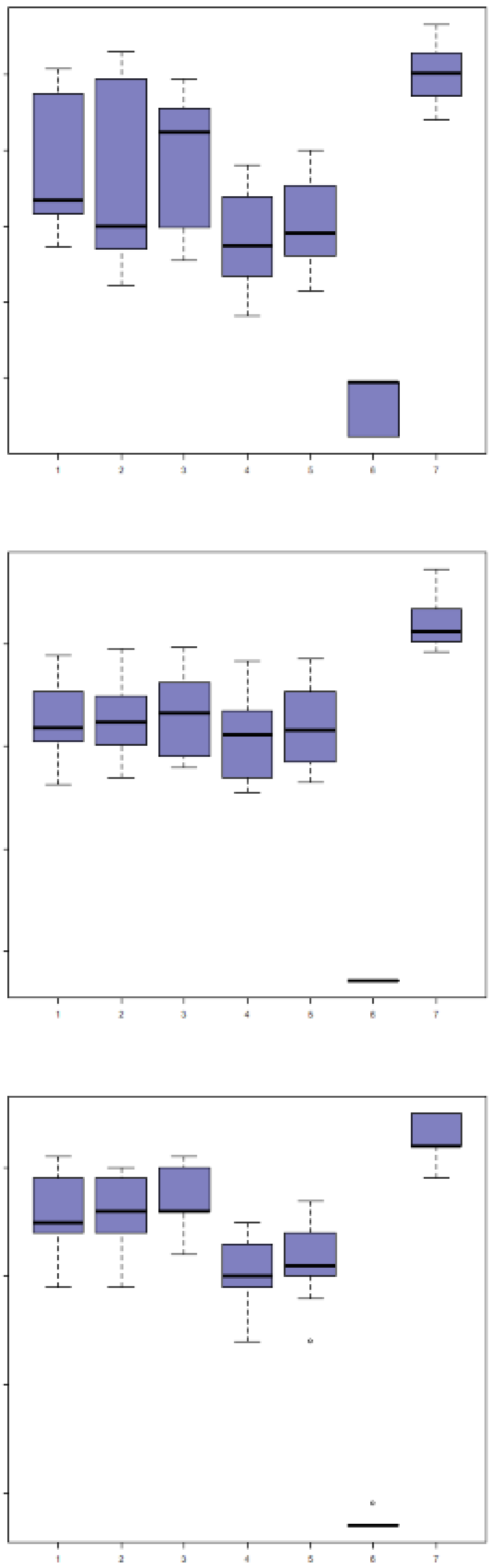
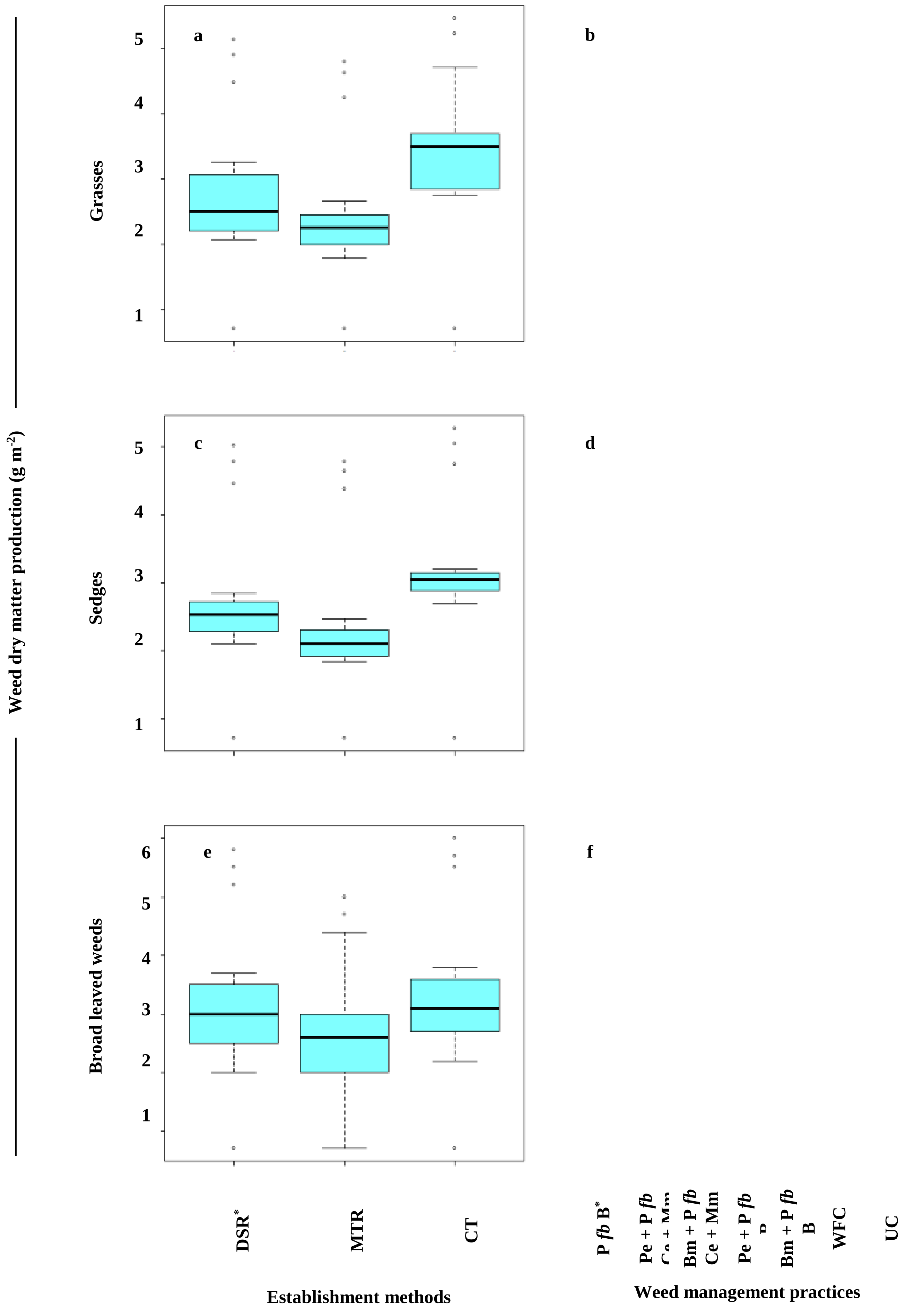
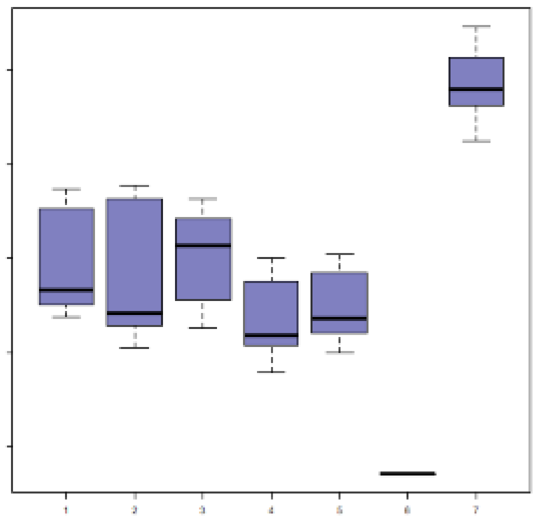
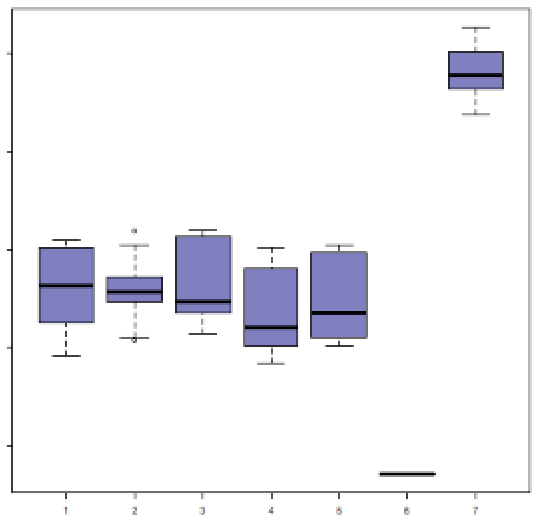


Figure 10. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed DMP at 15 DAS/DAT during *Rabi* 2022. * Refer to materials and methods for establishment methods and weed management practices.


Weed dry matter production (g m-2)
a
b
Grasses
c
d
Sedges
e
f
Broad leaved weeds
DSR*
MTR
CT
Establishment methods
P fb B*
Pe + P fb
Bm + P fb
Ce + Mm
Pe + P fb
Bm + P fb
B
WFC
UC
Weed management practices





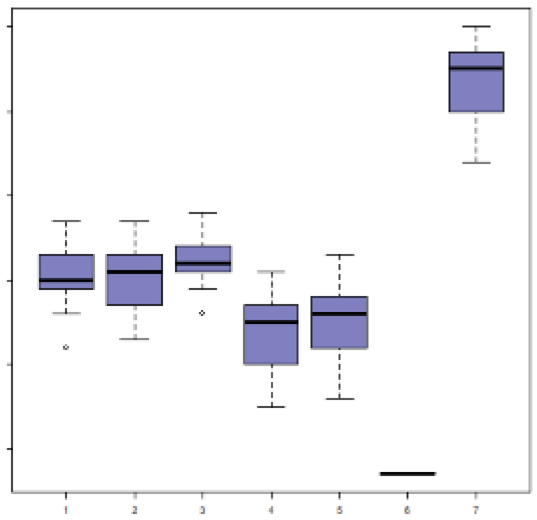
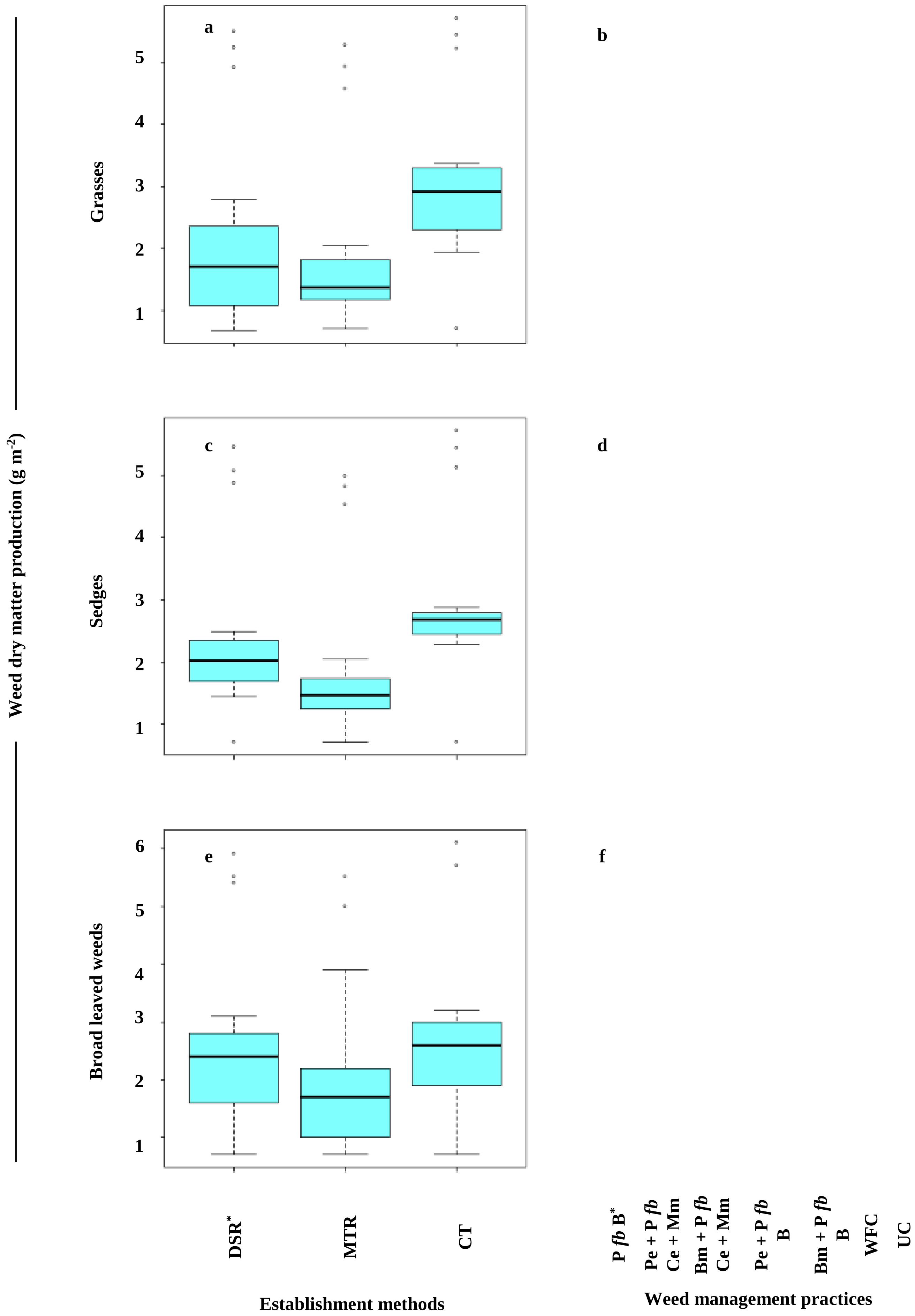


Figure 11. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed DMP at 30 DAS/DAT during *Rabi* 2022. * Refer to materials and methods for establishment methods and weed management practices.


Weed dry matter production (g m-2)
Grasses
Sedges
Broad leaved weeds
a
b
c
d
e
f
DSR*
MTR
CT
Establishment methods
P fb B*
Pe + P fb Ce + Mm
Bm + P fb Ce + Mm
Pe + P fb B
Bm + P fb B
WFC
UC
Weed management practices

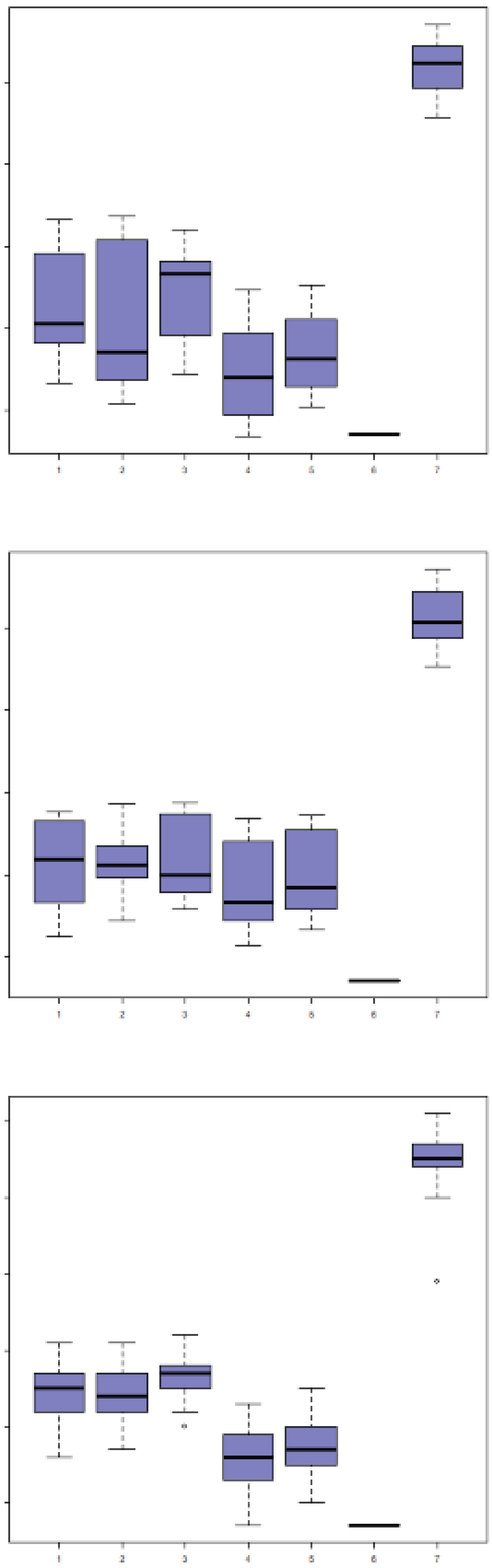


Figure 12. Effect of rice establishment methods and weed management practices on grasses (a,b), sedges (c,d) and BLW (e,f) weed DMP at 45 DAS/DAT during *Rabi* 2022. * Refer to materials and methods for establishment methods and weed management practices.

a

b

a

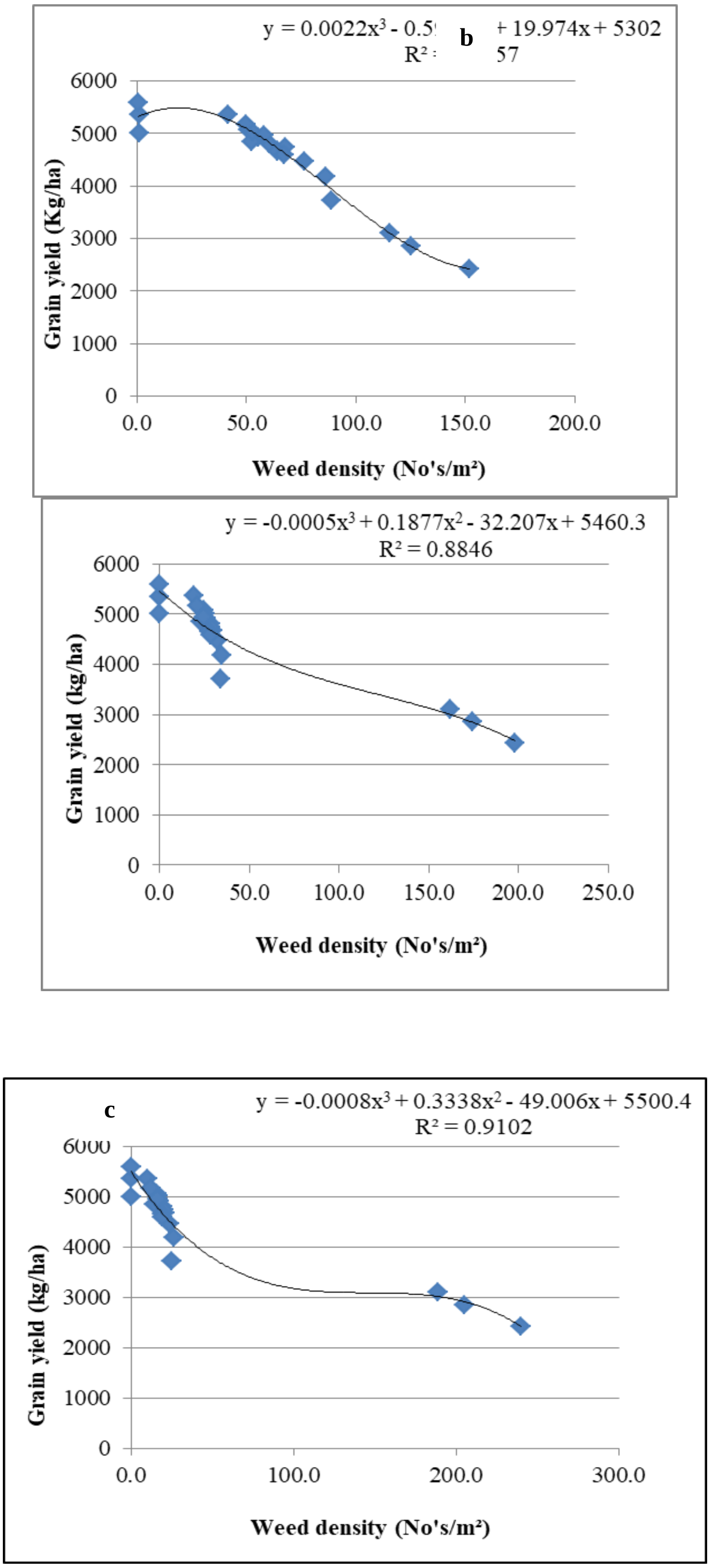


Figure 13. Relationship between grain yield and weed density/m^2 at (a) 15 DAS/DAT , (b) 30 DAS/DAT and (**c**) 45 DAS/DAT in *Kharif* 2021.

a

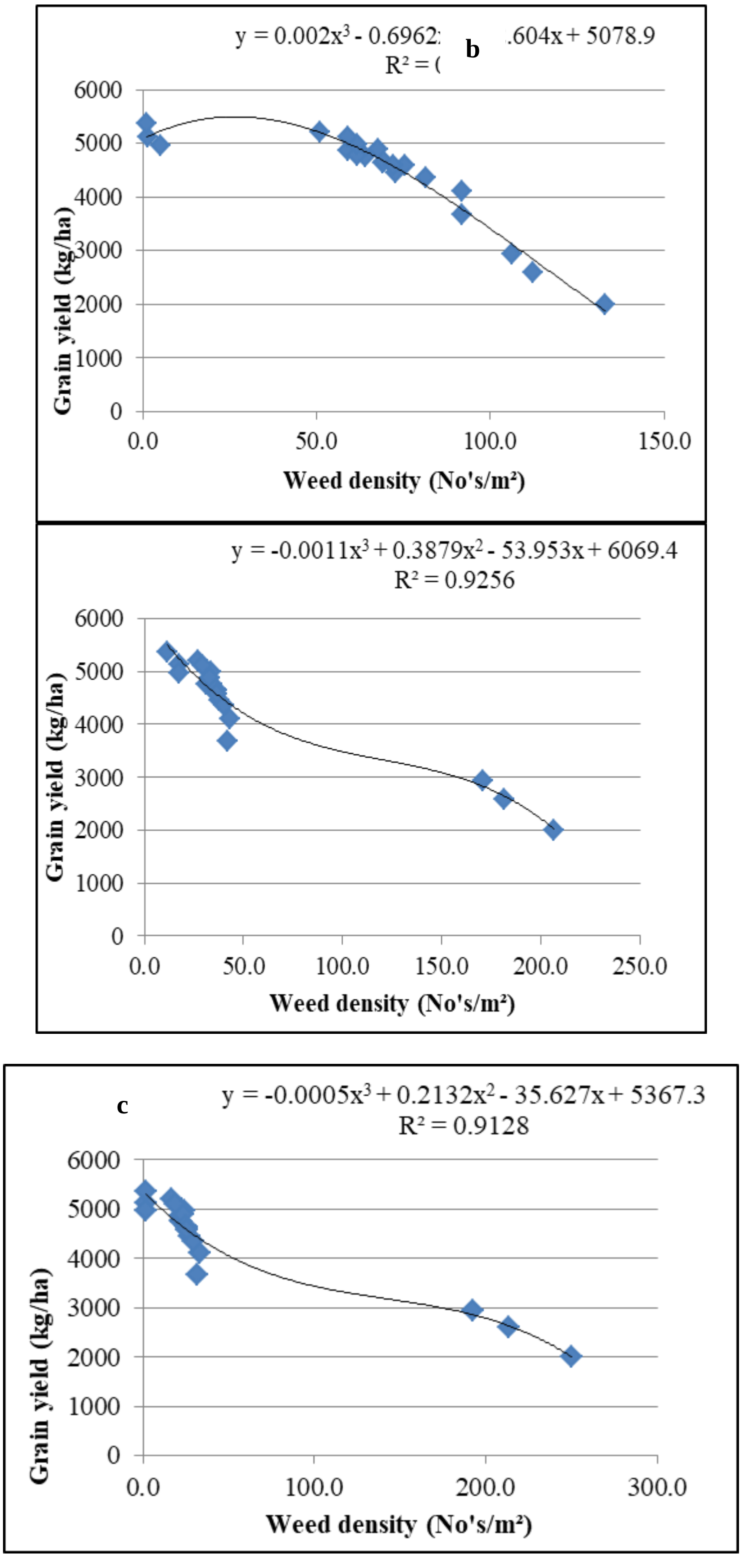


Figure 14. Relationship between grain yield and weed density/m^2 at (a) 15 DAS/DAT , (b) 30 DAS/DAT and (**c**) 45 DAS/DAT in *Rabi* 2022.

a

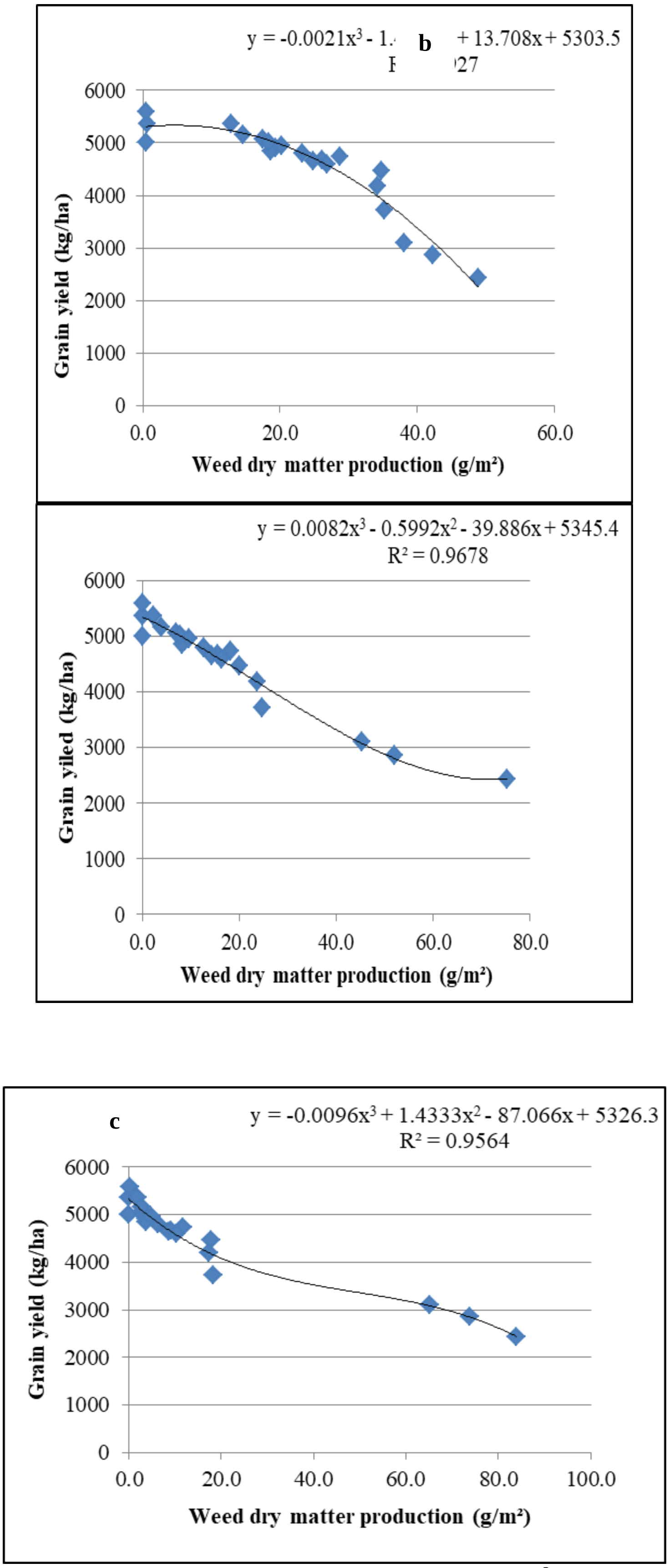


Figure 15. Relationship between grain yield and weed dry matter production (g/m^2) at (a) 15 DAS/DAT, (b) 30 DAS/DAT and (**c**) 45 DAS/DAT in *Kharif* 2021.

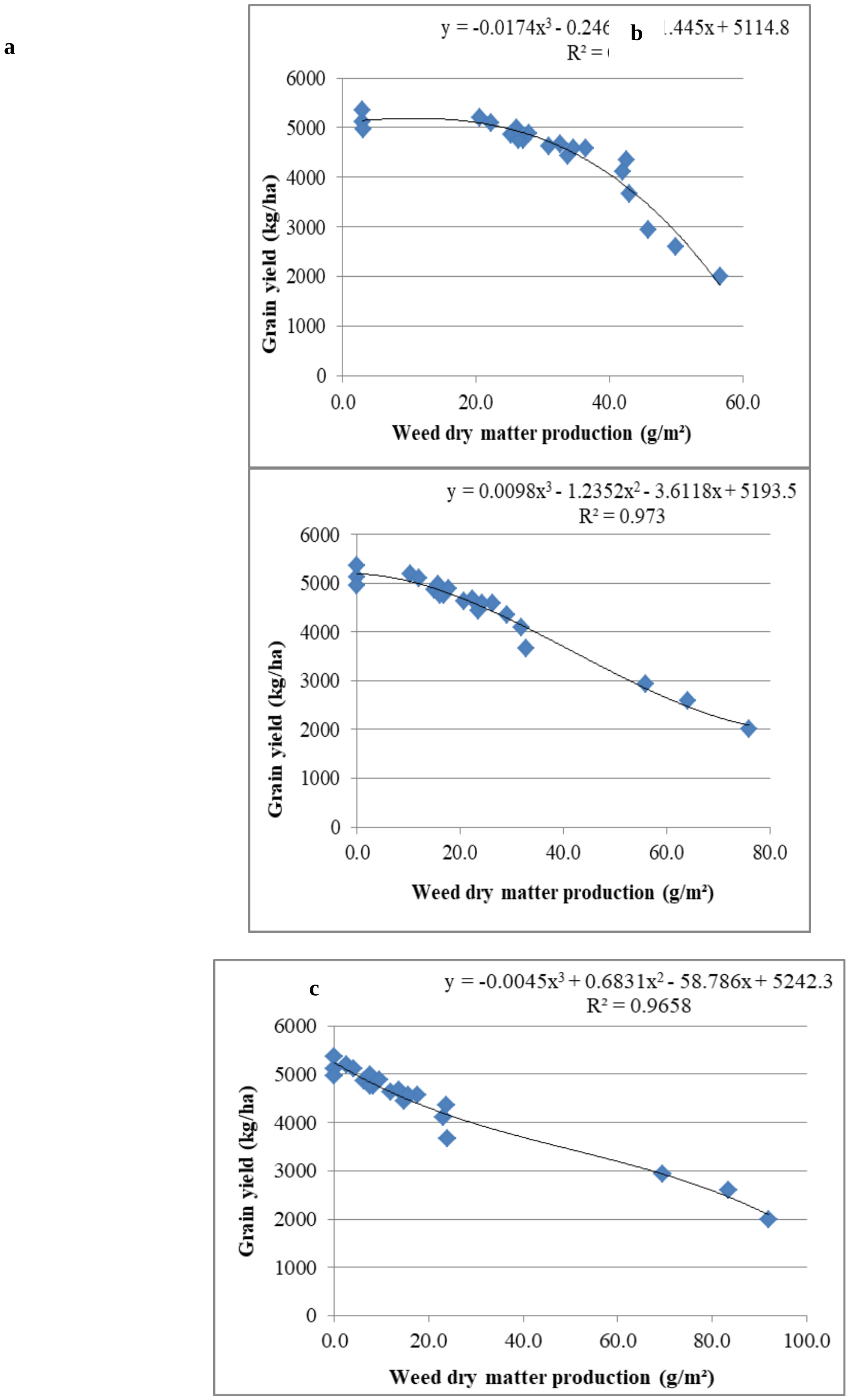


Figure 16. Relationship between grain yield and weed dry matter production (g/m^2) at (a) 15 DAS/DAT, (b) 30 DAS/DAT and (**c**) 45 DAS/DAT in *Rabi* 2022.