E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2024; SP-7(9): 1022-1027
Received: 22-07-2024
Accepted: 29-08-2024

Durgesh Kumar Maurya
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

RA Yadav
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

MZ Siddqui
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Naushad Khan
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

DD Yadav
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Ravindra Kumar
Department of Soil Science and Agricultural chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Mandeep Kumar
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Shravan Kumar Maurya
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Corresponding Author:
Durgesh Kumar Maurya
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Effect of crop establishment method and weed management practices on weed and rice yield under DSR system

Durgesh Kumar Maurya, RA Yadav, MZ Siddqui, Naushad Khan, DD Yadav, Ravindra Kumar, Mandeep Kumar and Shravan Kumar Maurya

DOI: https://doi.org/10.33545/2618060X.2024.v7.i9Sn.1657

Abstract
The experiment was conducted during the *kharif* season of 2022 and 2023 at Students' Instructional Farm, Department of Agronomy, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur-208002 (U.P.) India. The experiment was laid out in in Split Plot Deign with three replications and 16 treatment combination. In Main plot (Crop establishment method) P1- ZT-DSR + Sesbania co- culture, P2-Conventional till-DSR + Sesbania co- culture & Sub plot (Weed management) W1-Oxadiargyl @ 90 g a.i./ha (Pre. Emer.), W2-Pretilachlor 30.7% EC @ 1500-2000 ml/ha (Pre. Emer.), W3- Penoxasulam 1.02% + Cyhalofop - butyl 5.1% OD @ 2000-2500 ml/ha (Pre. Emer.), W4-Pretilachlor 30.7% + Pyrazosulfuron ethyl 0.75% WG @ 2000 g/ha (Pre. Emer.), W5-Oxadiazon @ 500-750 g. a.i./ha (Pre. Emer.), W6 - Oxyflurofen @ 150-250 g/ha (Pre. Emer.), W7-Hand weeding at 15, 30 and 45 DAS, W8-Untreated control. Higher growth attributing characters such as higher plant height, tillers, dry matter accumulation and leaf area index at different crop stages along with maximum grain yield were recorded with ZT-DSR + Sesbania co- culture, and in weed management practices three hand weeding at 15, 30 DAS and 45 DAS significantly enhanced key growth parameters in direct seeded rice.

Keywords: Herbicide, direct seeded rice (DSR), crop establishment method, weed management, rice yield, weed suppression

Introduction
Rice (*Oryza saliva* L.) is one of the most important staple food crops, which supplies major source of calories for about 45 percent of world population, particularly to the people of Asian countries. Rice stands second in the world after wheat in area and production. It occupies an area of 165.68 million hectares with an annual production of 514.57 million tonnes, with a productivity of 4640.43 kg ha^{-1} in the world [1]. Asia produces and consumes 90 percent of world's rice. Among the rice growing countries, India ranks first in area followed by China and Bangladesh. Rice is a major cereal crop of India occupied an area of 47.83 million hectare and production of 135.76 million tonnes with average productivity of 4260 kg ha^{-1}. In Uttar Pradesh, rice is cultivated in an area of 5.93 million hectares with an annual production of 12.50 million tonnes with average productivity of 2129 kg ha^{-1} [2].
Rice production is dependent on mainly climatic factors, but the most detrimental is availability of soil moisture. However, production and productivity of the crop is also determined by soil fertility, planting methods, and other biotic and abiotic factors which either directly or indirectly affect its growth and development. There are different rice planting methods, but the most common ones are transplanting and direct sowing. Transplanting of rice seedlings in the traditional way is a laborious, time consuming and causes drudgery.Whereas, direct sowing of rice crop may be prone to late moisture stress in dryland areas, where, late onset and early withdrawal of rain prevail. In rice crop production, the planting methods have an impact on the growth and yield besides cost of cultivation and labour requirement.
New method of rice establishments- zero till (ZT) rice have the potential to reduce costs and increase sustainability of irrigated rice culture while maintaining yield [3].

DSR on raised and flat beds omits the deleterious effects of puddling on soil structure and fertility, improves water and nutrient-use efficiency [4]. Growing rice under alternate wetting and drying conditions on raised beds or ZT on flat beds in rice-wheat cropping systems in humid tropical regions showed promising results, but this practice still needs further development [5].

Traditional planting methods in rice such as paddled transplanted rice require large amount of water, energy and labour, which are becoming increasingly scarce and expensive, Agriculture share of fresh water supplies is likely to decline by 8-10% because of increasing competition from the urban and industrial sectors. To ensure food security in Asia, it is imperative to identify rice production methods that require less irrigation water than the conventional transplanted rice [6] to reduce the cost of cultivation and energy consumption, to sustain productivity, and to increase the profit margin of farmers' [7]. As such agriculture is affected by the changes in the global environmental conditions, but agriculture is also contributes to about 20% of the emissions of greenhouse gases, notably methane and nitrous oxide. It estimated that India's climate could become under warmer conditions of increased atmospheric carbon dioxide. The average temperature change is predicted to be in the range of 1.5 °C to 4.5 °C with a doubling in CO_2 concentrations. The change in climate would impact agriculture production especially rice crops which is mainly grown along the coastal region in India. Rice is most sensitive to high temperature at flowering stage; temperature higher than 35 °C at flowering stage may increase spikelet sterility.

Dry seeding of rice seed can be sown under ZT conditions thus saving fuel and labour costs [8] due to lesser wear and tear losses of machine and reduction in cost of the tillage operation. In this system, bio-tillage replaces mechanical tillage. Higher organic matter under ZT system favours soil macro- and micro-fauna build up and thus maintain an open-pore structure of the soil. Retention of residues on the soil surface conserves soil moisture and also serves as the source of energy for soil life for bio-tillage. Other benefits of ZT drill are saving in seed and fertilizer, reduction of soil erosion, improvement of soil physical and chemical properties and conservation of soil moisture [9], higher yields at lower production costs and reduction of global warming potential by 20-44 percent over conventional transplanting [10].

It is generally observed that crop lodging is less in ZT due to higher root mass and depth than conventional tillage, more particularly compared to rotavator tillage and broadcasting wherein roots become surface feeder due to sub-surface compaction [11]. It can reduce weed problems and make management easier if weeds are managed effectively in the initial 2-3 years. Besides, it may also reduce weed emergence of some weed species because seeds at the soil surface are more prone to predation [12] and dessication [13].

In DSR culture, weeds are one of the biggest problems because of the absence of flooding during early stages as all types of weeds namely grasses, sedges and broad leaved weeds emerge simultaneously at high density with rice seedlings. This invites severe competition between weeds and rice thus reducing the crop yield on an average of 50-60 percent. Losses can be severe in DSR as the rice and weed seedlings are at similar growth stages. The phenotypic appearance of grassy weeds, especially *Echinochloa colona* and *Echinochloa crusgalli*, closely resembles that of rice seedlings and it is difficult to differentiate such weeds and remove them in the early stages. The aerobic soil conditions and dry-tillage practices, besides alternate wetting and drying conditions, are conducive for germination and growth of highly competitive weeds, which cause grain yield losses of 50-91%.

In "Brown Manuring" practice, both rice and Sesbania crops are seeded together and allowed to grow for 25-30 days. Subsequently Sesbania intercrop is knocked down with 2, 4-D at 500 g ha^{-1} [14]. This technology reduces weed population by nearly half without any adverse effect on rice yield. Also, Sesbania surface mulch decomposes very fast to supply N and other recycled nutrients [15].

Climate change also affects the effectiveness of herbicides. Drought stressed weeds are more difficult to control with post-emergent herbicides than plants that are actively growing for example, systemic herbicides that are translocated within the weed need active plant growth stage to be effective. Pre-emergent herbicides or herbicides absorbed by plant roots need soil moisture and actively growing roots to reach their target sites. Occurrence of drought has the potential to reduce the effectiveness of pre-emergent herbicides. It is expected that climate change will bring about a shift in the floral composition of several ecosystems at higher altitudes and latitudes, as changes in temperature and humidity will be reflected on flowering, fruiting and seed dormancy. In general, any direct or indirect consequence of increasing CO_2 or climate change, which differentially affects the growth or fitness of weeds and crops, will alter crop weed competitive interactions. The result may be favouring the weed in one case, or the crop may benefit in another situation.

Among the various factors responsible for low rice production, weeds are considered to be as one of the major limiting factors due to manifold harmful effects. Weed infestation reduces the grain yield by 70-80% in aus rice (early summer), 30-40% for transplanted aman rice (late summer) and 22-36% for modern boro rice cultivars (winter rice) reported that the extent of yield reduction due to unchecked weed growth has been estimated on account of 20-25% for transplanted rice and 40-50% for direct-seeded rice. Rice grain production in India suffers yearly loss of 15 million tonnes due to weed competition reported that when weed control was optimum and crop establishment was good, yields of direct-seeded rice could equal to those of transplanted crops.

Subsistence farmers of the tropics spend more time, energy and money on weed control than on any other aspects of crop production. Poor weed control is one of the major factors responsible for reduction in yield including type of weed flora and their intensity. Therefore, weed control with minimum cost and less adverse effect on environment is of prime importance. The traditional methods of weed control practices include preparatory land tillage, hand weeding by hoe and hand pulling. Usually two/three hand weeding is normally required for optimum yield from rice crop keeping in view the nature of weeds and their intensity. Hand weeding is very laborious, time consuming and expensive. In addition, during the peak period, the availability of labour is also becoming a serious problem by time. However, herbicides are used successfully for weed control in rice fields for rapid effect, easier to application and low cost involvement in comparison to the traditional methods of hand weeding.Herbicidal weed control methods offer an advantage to save labour and money which was cost effective.

Weed infestation in dry seeded rice (*Oryza sativa* L.) is one of the major constraints for low yield and the depression of yield due to weed competition may be as high as 40 to 100% depending upon the intensity and type of weed flora. Prolonged use of herbicides with same mode of action can result in development of herbicide resistance in weeds (.Repeated use of any single herbicide in a crop also generates a shift in the composition of weed flora with the result that secondary weeds may become of primary concern.

Materials and Methods

The experiment was conducted at Students' Instructional Farm, Department of Agronomy, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur- 208002 (U.P.) during *kharif* season of 2022 and 2023. Which is situated in the alluvial tract of Indo-Gangatic plain in central part of Uttar Pradesh between 25026' to 26058' North latitude, 79031' to 31034' East longitude and on the altitude of 125.9 meters. The irrigation facilities are adequately available on this farm. The mean weekly maximum and minimum temperature during the crop growth period ranged from 27.00 °C to 43.90 °C and 9.90 °C to 29.50 °C, during 2022 and 26.42 °C to 42.20 °C and 11.40 °C to 29.80 °C during 2023, respectively. The crop availed maximum relative humidity 94%, 93% against minimum 42% and 37% during 2022 and 2023, respectively. Total rainfall of 836.20 mm and 747.80 mm was received during crop period 2022 and 2023, respectively. During the crop growing period, the mean weekly highest and lowest total rainfall recorded ranging from 0.0 mm to 159 mm and 0.0 mm to 128 mm and evaporation ranged from 2.60 to 8.80 mm day-1 and 2.01 to 7.09 mm day-1 during 2022 and 2023, respectively. The weekly mean wind velocity during the experimental season fluctuated between 1.60 to 10.20 km h-1 and 1.20 to 9.60 km h-1during 2022 and 2023 respectively. Bright sun shine also recorded in range from 0.90 to 8.90 day hr-1 and from 0.20 to 9.10-day hr-1 during 2022 and 2023 respectively. Meteorological observation recorded during vegetative, reproductive and maturity stages of Rice crop. The experiment was laid out in Split Plot Deign with three replications and 16 treatment combination. In Main plot (Crop establishment method) P_1- ZT-DSR + Sesbania co- culture, P_2- Conventional till-DSR + Sesbania co- culture & Sub plot (Weed management) W_1-Oxadiargyl @ 90 g a.i./ha (Pre. Emer.), W_2- Pretilachlor 30.7% EC @ 1500-2000 ml/ha (Pre. Emer.), W_3- Penoxasulam 1.02% + Cyhalofop - butyl 5.1% OD @ 2000-2500 ml/ha (Pre. Emer.), W_4-Pretilachlor 30.7% + Pyrazosulfuron ethyl 0.75% WG @ 2000 g/ha (Pre. Emer.), W_5 -Oxadiazon @ 500-750 g. a.i./ha (Pre. Emer.), W_6 -Oxyflurofen @ 150-250 g/ha (Pre. Emer.), W_7-Hand weeding at 15, 30 and 45 DAS, W_8-Untreated control. The suitable crop variety are Sarju-52.

Results and Discussion

Plant height

The results of growth attributes of paddy were shown in Table 1. The plant height was significantly influenced due to crop establishment methods during both the years of experimentation 2022 and 2023. The plant height of rice was recorded significantly higher at all the stages of crop growth except 30 DAS under zero till direct seeded rice + brown manuring (ZT-DSR + BM) treatment (55.3, 82.3 and 80.4 cm in 2022 as well as 52.6, 78.2 and 76.4 cm in 2023) at 60, 90 DAS and at harvest stage, respectively similar result shown by Muthukrishan *et. al.* [16]. The lowest plant height at all the growth stages i.e. 60, 90 DAS and at harvest stages of crop growth were recorded when rice was grown under conventional till-DSR + brown manuring (CT-DSR + BM). And weed management Significant increases in plant height at all the crop growth stages were recorded due to weed management treatments in both the years of experimentation. In both the years of study the highest plant height was recorded with three hand weeding at 15, 30 DAS and 45 DAS followed by Pretilachlor 30.7% + Pyrazosulfuron ethyl 0.75% WG @ 2000 g/ha and lowest with control treatment (Table 1).

Number of tiller

The data on number of tiller at different growth stages of rice as influenced by crop establishment methods are presented in Table 4.13. Number of tiller was significantly influenced due to crop establishment methods during both the years of experimentation 2022 and 2023. The number of tiller of rice was recorded significantly higher at all the stages of crop growth except 30 DAS under zero till direct seeded rice + brown manuring (ZT-DSR + BM) treatment (351, 329 and 310 m^{-2} in 2022 as well as 367, 348 and 326 m^{-2} in 2023) at 60, 90 DAS and at harvest stage, respectively same as reported by Farooq *et. al.* [17]. The lowest number of tiller at all the growth stages i.e. 60, 90 DAS and at harvest stages of crop growth were recorded when rice was grown under conventional till-DSR + brown manuring (CT-DSR + BM). And weed management Significant increases in number of tiller at all the crop growth stages were recorded due to weed management treatments in both the years of experimentation. In both the years of study the highest number of tiller was recorded with three hand weeding at 15, 30 DAS and 45 DAS followed by Pretilachlor 30.7% + Pyrazosulfuron ethyl 0.75% WG @ 2000 g/ha and lowest with control treatment (Table 2).

Dry matter production

The data related to dry matter accumulation at different growth stages of rice as influenced by crop establishment methods are presented in Table 3. Dry matter accumulation at 60, 90 DAS and at harvesting stages were significantly influenced due to crop establishment methods during both the years of experimentation. The total dry matter accumulation was recorded significantly higher at 60, 90 DAS and at maturity stages under zero till direct seeded rice + brown manuring (ZT-DSR + BM) treatment followed by conventional till-DSR + brown manuring (CT-DSR + BM) during both the years of experimentation similar result reported Walia *et. al.* [25]. And weed management Significant increases in plant height at all the crop growth stages were recorded due to weed management treatments in both the years of experimentation similar result sown by Mishra *et al.* [18]. Weed management influenced the dry matter accumulation at 60, 90 DAS and at maturity stages during 2022 and 2023. three hand weeding at 15, 30 DAS and 45 DAS followed by Pretilachlor 30.7% + Pyrazosulfuron ethyl 0.75% WG @ 2000 g/ha recorded significantly higher total dry matter production as compared to control treatment (Table 3).

Leaf area index

The result showed on leaf area index at different growth stages of rice as influenced by crop establishment methods are presented in Table 5. Leaf area index (LAI) at 60, 90 DAS and at maturity stage was significantly influenced due to crop establishment methods during both the years of experimentation similar result reported Sharma *et al.* [21]. The LAI at 60, 90 DAS and at maturity stages recorded significantly higher dry matter accumulation when rice was grown under zero till direct seeded rice + brown manuring (ZT-DSR + BM) of sesbania as compared to conventional till-DSR + brown manuring (CT-DSR + BM) during both the years of experimentation similar result reported Tripathi *et al.*, [22]. The non-significant effects of planting methods were recorded at 30 DAS. And significant increase in LAI was recorded due to weed management in both the years of experimentation. The LAI was recorded significantly higher with three hand weeding at 15, 30 DAS and 45 DAS followed by Pretilachlor 30.7% + Pyrazosulfuron ethyl 0.75% WG @ 2000 g/ha and lowest was observed in control treatment similar result reported Yadav *et. al.* [23] (Table 4).

Table 1: Effect of planting methods and weed management practices on plant height (cm) at various stages

	30 DAS			60 DAS			90 DAS			At harvest		
	2022	**2023**	**Pooled**	**2022**	**2023**	**Pooled**	**2022**	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
Planting method (PM)												
CT-DSR + BM	32.3	34.7	33.5	55.3	59.4	57.3	82.3	86.5.	84.4	80.4	85.4	82.9
ZT-DSR + BM	31.6	33.2	32.4	52.6	56.0	54.3	78.2	83.0	80.6	76.4	81.9	79.1
SEm±	1.0	1.0	1.0	1.2	1.3	1.2	1.4	1.1	1.2	0.9	1.2	1.0
CD (P=0.05)	NS	NS	NS	4.1	4.6	4.3	5	3.9	4.4	3.3	4.2	3.7
Weed management (WM)												
W1	31.4	33.2	32.3	55.5	60.4	57.9	74.5	78.7	76.6	72.5	77.4	74.9
W2	32.1	33.5	32.8	57.1	62.3	59.7	76.0	81.2	78.6	74.0	79.7	76.8
W3	32.4	33.7	33.0	57.4	62.8	60.1	79.1	83.1	81.1	78.0	82.2	80.1
W4	32.6	33.9	33.2	59.8	64.3	62.0	79.5	83.9	81.7	78.2	82.3	80.2
W5	30.9	32.7	31.8	52.5	57.5	55.0	72.8	75.5	74.1	70.5	74.4	72.4
W6	31.1	32.9	32.0	54.5	59.5	57.0	73.3	77.6	75.4	71.5	76.4	73.9
W7	32.8	34.3	33.5	61.8	66.5	64.1	81.5	86.1	83.8	79.4	85.4	82.4
W0	25.1	24.8	25.1	47.3	52.2	49.7	62.6	67.8	65.7	60.7	65.2	62.9
SEm±	0.9	0.9	0.9	1.0	1.1	1.05	1.4	1.3	1.35	1.8	1.6	1.7
CD (P=0.05)	NS	NS	NS	3.0	3.3	3.1	4.2	3.9	4.05	5.2	4.8	5.0

Table 2; Effect of planting methods and weed management practices on No. of tiller (m^{-2}) at various stages

	No. of tiller (m-2) at 30 DAS			No. of tiller (m-2) at 60 DAS			No. of tiller (m-2) at 90 DAS			No. of tiller (m-2) at Harvesting		
	2022	**2023**	**Pooled**	**2022**	**2023**	**Pooled**	**2022**	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
Planting method (PM)												
CT-DSR + BM	175	176	175	351	367	359	329	348	338	310	326	318
ZT-DSR + BM	180	189	184	355	371	363	335	355	345	314	330	322
SEm±	4.57	5.11	4.84	7.12	8.01	7.56	6.32	7.03	6.67	5.40	6.10	5.75
LSD (P=0.05)	11.65	14.75	13.20	16.50	18.30	17.40	14.30	16.40	15.35	12.30	14.50	13.40
Weed management (WM)												
W1	163	174	168.5	245	255	250	219	332	275.	286	302	294
W2	167	176	171.5	248	259	253.	221	335	278	291	307	299
W3	170	189	179.5	349	361	355	325	339	332	295	311	303
W4	174	185	179.5	356	369	362.	329	344	336.	297	313	305
W5	158	168	163	238	248	243	212	323	267.	303	319	311
W6	160	169	164.	241	252	246.	215	327	271	307	323	315
W7	185	194	189.	360	376	368	340	360	350	316	332	324
W0	170	182	176	340	351	345.	315	326	320.	291	307	299
SEm±	4.06	5.43	4.74	7.02	7.80	7.41	6.42	7.32	6.87	5.70	6.80	6.25
LSD (P=0.05)	10.63	13.27	11.95	17.40	17.80	17.60	15.10	17.30	16.20	13.10	14.90	14.01

Table 3: Effect of planting methods and weed management practices on dry matter production (g m-2) at various stages

	30 DAS			60 DAS			90 DAS			At harvest		
	2022	**2023**	**Pooled**	**2022**	**2023**	**Pooled**	**2022**	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
Planting method (PM)												
CT-DSR + BM	222.9	229.8	226.3	432.5	456.9	444.7	743.6	795.9	769.7	750.5	787.1	768.8
ZT-DSR + BM	220.4	227.3	223.8	401.9	425.1	413.5	710.9	760.4	735.6	703.7	738.2	720.9
SEm±	3.2	3.3	3.25	7.1	7.6	7.35	7.2	7.9	7.55	12.4	13	12.7
LSD (P=0.05)	NS	NS		24.9	14.4	19.65	25.4	27.9	26.6	43.7	46.9	44.8
Weed management (WM)												
W1	218.6	225.5	222.0	385.4	411.5	398.4	660.6	715.4	688.0	707.8	746.7	727.2
W2	219.8	226.6	223.2	396.6	422.2	409.4	682.4	733.6	708.0	718.6	757.9	738.2
W3	220.9	227.7	224.3	405.7	431.6	418.6	707.5	760.8	734.1	729.7	769.3	749.5
W4	221.3	228.2	224.7	415.2	441.7	428.4	732.7	787.8	760.2	740.1	779	759.5
W5	216.2	223.4	219.8	363.6	389.7	376.6	606.4	652.5	629.4	691.5	727.8	709.6
W6	217.4	224.5	220.9	374.5	401.6	388.0	627.2	680.4	653.8	700.8	738.9	719.8
W7	222.8	229.7	226.2	428.3	455.6	441.9	755.5	812.3	783.9	748.1	787.5	767.8
W0	215.6	220.4	218.0	387.7	400.8	394.2	565.5	633.4	599.4	657.7	683.0	670.3
SEm±	4	4.1	4.05	4.9	4.9	4.9	6.8	7.4	7.1	8.5	9	8.7
LSD (P=0.05)	NS	NS	NS	14.4	26.6	20.5	20.1	21.8	20.9	24.8	26.4	25.

Table 4: Effect of planting methods and weed management practices on leaf area index at various stages

	30 DAS			60 DAS			90 DAS			At harvest		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Planting method (PM)												
CT-DSR + BM	1.85	1.96	1.87	3.05	3.23	3.14	3.89	4.16	4.02	3.46	3.63	3.54
ZT-DSR + BM	1.78	1.83	1.80	2.77	2.94	2.85	3.51	3.76	3.63	3.16	3.31	3.23
SEm±	0.024	0.024	0.024	0.003	0.005	0.004	0.006	0.008	0.007	0.006	0.008	0.007
LSD (P=0.05)	NS	NS	NS	0.011	0.019	0.015	0.021	0.028	0.0245	0.02	0.022	0.021
Weed management (WM)												
W1	1.7	1.76	1.73	2.75	2.9	2.82	3.15	3.4	3.27	2.85	2.95	2.90
W2	1.75	1.81	1.78	2.86	2.97	2.88	3.29	3.55	3.42	2.94	3.08	3.01
W3	1.78	1.83	1.80	2.97	3.16	3.06	3.58	3.84	3.71	3.17	3.34	3.25
W4	1.81	1.87	1.84	3.06	3.25	3.15	3.87	4.16	4.01	3.49	3.67	3.58
W5	1.65	1.71	1.68	2.67	2.75	2.71	2.86	3.01	2.93	2.52	2.52	2.52
W6	1.67	1.73	1.75	2.70	2.83	2.76	3.01	3.25	3.13	2.68	2.85	2.76
W7	1.85	1.91	1.88	3.24	3.45	3.34	4.05	4.35	4.25	3.64	3.83	3.73
W0	1.45	1.5	1.47	2.2	2.26	2.23	2.34	2.72	2.53	2.12	2.26	2.16
SEm±	0.033	0.034	0.033	0.003	0.005	0.004	0.005	0.005	0.005	0.005	0.008	0.006
LSD (P=0.05)	NS	NS	NS	0.01	0.016	0.013	0.015	0.016	0.015	0.015	0.022	0.018

Conclusion

It can be concluded from the present investigation that the crop establishment methods ZT-DSR + Sesbania co- culture, and in weed management practices three hand weeding at 15, 30 DAS and 45 DAS significantly enhanced key growth parameters in direct seeded rice. This treatment resulted in higher plant height, increased tiller, greater dry matter accumulation, and leaf area index compared to conventional till-DSR + brown manuring (CT-DSR + BM) and other weed management practices.

References

1. Anonymous. Directorates of economics and statistics. Department of Agriculture and Cooperation, Govt. of India, New Delhi; c2021-22.
2. FAO (Food and Agricultural Organization); c2021. Available from: http://www.fao.org/home/en/
3. Hobbs PR, Gupta RK. Rice-wheat cropping systems in Indo-Gangetic plains: issues of water productivity in relation to new resource conserving techniques. In: Proceedings of the Water Productivity Workshop; c2022 12-14 Nov. IWMI, Sri Lanka.
4. Timsina J, Connor DJ. Productivity and management of rice-wheat cropping systems: issues and challenges. Field Crops Res. 2021;69(2):93-132.
5. Humphreys E, Meisner C, Gupta R, Timsina J, Beecher HG, Lu TY, *et al*. Water savings in rice-wheat systems. Plant Prod Sci. 2015;8(2):242-258.
6. Cabangon RJ, Tuong TP, Janiya JD. Rice grown on raised beds: effect of water regime and bed configuration on rice yield, water input and water productivity. In: Roth CH, Fischer RA, Meisner CA, editors. Evaluation and performance of permanent raised bed cropping systems in Asia, Australia and Mexico. Proceedings of a workshop; 2015;121:92-105.
7. Singh G, Singh Y, Singh VP, Singh RK, Singh P, Johnson DE, *et al*. Direct seeding as an alternative to transplanted rice for the rice-wheat system of the Indo-Gangetic plains: sustainability issues related to weed management. In: Proceedings of an International Congress; c2003 12-14 Nov. p. 7-9.
8. Rao AN, Nagamani A. Available technologies and future research challenges for managing weeds in dry-seeded rice in India. In: Proceedings of the 21st Asian Pacific Weed Science Society Conference; c2007 2-6 Oct. p. 391-400.
9. Gupta RK, Naresh RK, Hobbs PR, Ladha JK. Adopting conservation agriculture in the rice-wheat system of the Indo-Gangetic Plains: New opportunities for saving water. In: Bouman BAM, Hengsdijk H, Hardy B, Bindraban PS, Tuong TP, Ladha JK, editors. Water-Wise Rice Production. Proceedings of a Thematic Workshop on Water-Wise Rice Production; c2019.
10. Kumar V, Ladha JK. Recent developments in direct-seeding of rice. Adv Agron. 2011;111:297-413.
11. Jat ML, Singh RG, Sidhu HS, Singh UP, Malik RK, Kamboj BR, Jat RK, *et al*. Resource conserving technologies in South Asia: frequently asked questions. Technical Bulletin. International Maize and Wheat Improvement Center, New Delhi, India; c2010. p. 44.
12. Spafford HJ, Minkey DM, Gallagher RS, Borger CP. Variation in post-dispersal weed seed predation in a crop field. Weed Sci. 2016;54(2):148-155.
13. Mohler CL, Galford AE. Weed seedling emergence and seed survival: separating the effects of seed position and soil modification by tillage. Weed Res. 2017;37(2):147-155.
14. Singh G. Integrated weed management in direct-seeded rice. In: Singh Y, Singh VP, Chauhan B, Orr A, Mortimer AM, Johnson DE, Hardy B, editors. Direct seeding of rice and weed management in the irrigated rice-wheat cropping system of the Indo-Gangetic Plains. Los Baños (Philippines): International Rice Research Institute; Pantnagar (India): Directorate of Experiment Station, GB Pant University of Agriculture and Technology; c2018. p. 161-176.
15. Gopal R, Jat RK, Malik RK, Kumar V, Alam MM, Jat ML, *et al*. Direct dry seeded rice production technology and weed management in rice-based systems. Technical Bulletin. International Maize and Wheat Improvement Center, New Delhi, India; c2020. p. 28.
16. Muthukrishan P, Budhar MN, Ponnuswamy K, Santhi P. Studies on weed management in direct sown rice under puddle conditions. Indian J Weed Sci. 2016;28(3&4):214-215.
17. Farooq M, Siddique KHM, Rehman H, Aziz TD, Lee J, Wahid A. Rice direct seeding: Experiences, challenges and opportunities. Soil Tillage Res. 2021;111:87-98.
18. Mishra JS, Singh VP. Integrated weed management in zero-till direct-seeded rice (*Oryza sativa*) - wheat (*Triticum aestivum*) cropping system. Indian J Agron. 2017;52(3):198-203.
19. Pane H, Noor ES, Dizon M, Mortimer AM. Weed

communities of gogorancah rice and reflections on management. In: Tuong TP, Kam SP, Wade L, Pandey S, Bouman BAM, Hardy B, editors. Characterizing and understanding rainfed environments. Proceedings of the International Workshop on Characterizing and Understanding Rainfed Environments; c2020. p. 269-287.

20. Rahman M, Juraimi AS, Jaya Suria ASM, Man AB, Anwar P. Response of weed flora to different herbicides in aerobic rice system. Sci. Res. Essays. 2012;7(1):12-23.
21. Sharma RK, Singh R. Furrow irrigated raised bed planting system: an efficient input usage production technology. Indian Farming. 2022;52:25-26.
22. Tripathi SC, Nagaranjan S, Chauhan DS. Evaluation of zero-tillage in wheat (*Triticum aestivum*) under different methods of rice (*Oryza sativa*) transplanting. Indian J Agron. 2022;44(2):219-222.
23. Yadav DS, Sushant, Mortimer AM, Johnson DE. Studies on direct seeding of rice, weed control, and tillage practices in the rice-wheat cropping system in eastern Uttar Pradesh. In: Singh Y, Singh VP, Chauhan B, Orr A, Mortimer AM, Johnson DE, Hardy B, editors. Direct seeding of rice and weed management in the irrigated rice-wheat cropping system of the Indo-Gangetic Plains. Los Baños (Philippines): International Rice Research Institute; Pantnagar (India): Directorate of Experiment Station, GB Pant University of Agriculture and Technology; c2018. p. 131-137.
24. Yaduraju NT, Mishra JS. Weed management in rice with special orientation to export SAARC RICE EXPO 2004. Maharashtra Chamber of Commerce and Industry and Rice Exporters Association of Pakistan, Mumbai, India; c2014. p. 111-115.
25. Walia US, Bhullar MS, Nayyar S, Walia SS. Control of complex weed flora of dry-seeded rice (*Oryza sativa* L.) with pre and post-emergence herbicides. Indian J Weed Sci. 2018;40(3&4):161-164.