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Effect of Planting Density and Weeding Regime on Yield Attributes and Yield of Drum Seeded Rice (*Oryza sativa* L.)

B. N. Sandeep Nayak, Md. Mujeeb Khan, K. Mosha, P. Prasuna Rani

Abstract **– Drum seeding of rice (*Oryza sativa* L.) involves a major change in the production practices for attaining optimal plant density and first-rate weed management practices for get in touch with higher productivity in the areas of Krishna Godavari zone of AP (INDIA). A field experiment was carried out to investigate the effects of weeding regime and planting density on yield attributes of drum seeded rice cv. NLR-33358 (*SOMASILA*). The maximum reduction of weed density and weed drymatter production was recorded in two cono weedings followed by two hand weedings at 20 and 40 DAS, pre-emergence application of pendimethalin @1 kg a.i. ha^{-1} post-emergence application of bispyribac sodium @ 20 g a.i ha^{-1} with a plant density of 71hills m^{-2}. But, plant density 47 hills m^{-2} was superior to other plant densities with respect to rice grain yield. The highest grain yield (4275 kg ha^{-1}) was achieved with plant density 47 hills m^{-2} (D_2) in combination of cono weedings twice (W_3) but remained at a par to hand weedings twice (4142 kg ha^{-1}). The next best treatment was -emergence application of pendimethalin @1 kg a.i. ha^{-1} along with post-emergence application of bispyribac sodium @ 20 g a.i ha^{-1}.**

Keywords **– Bispyribac-Sodium, Cono Weeding, Drum Seeding, Hand Weeding, Pendimethalin.**

I. Introduction

Rice (*Oryza sativa* L.) is the dominant staple food for many countries in Asia and Pacific, South and North America as well as Africa (Mobasser *et al*. 2007) and also is a staple food for nearly half of the world's seven billion population. However, more than 90 per cent of rice is consumed in Asia, where it is a staple food for a majority of the population, including the 560 million hungry people in the region (Mohanty, 2013). Globally, India stands first in rice area and second in production after China. It is also a staple food for more than 65 per cent of the Indian population and accounts for more than 42 per cent of food production.

The area under direct - seeded rice is increasing as farmers in India seek higher productivity and profitability to overcome increasing costs and scarcity of farm labour. One of the major reasons for non-remunerative rice production in recent times is augmented cost of cultivation because of scarce and costly farm labour during the peak period of farm operations. Establishing rice by transplanting is labour intensive and increasingly difficult due to higher cost and shortage of labour. Inadequate plant density with hired labour for transplanting is the major lacuna in this method (Ram *et al.* 2006).

Drum seeding is an alternative method to transplanting. It reduces labour requirement and performs as good as transplanting method at many places (Yadav and Singh, 2006). However, drum seeding method is subjected to severe weed infestation than conventionally puddled transplanted rice that leads to because of the absence of the size disparity between the crop and weed plants and the suppressive effect of standing water on weed growth at crop establishment.

Weeds compete with rice plant severely for space, nutrients, air, water and light by adversely affecting plant height, leaf architecture, tillering habit, shading ability, growth pattern and crop duration (Miah *et al.*1990). Weed depresses the normal yield of grains per panicle and grain weight (Bari et al. 1995). Subsistence farmers of the tropics spend more time, energy and money for weed control than any other aspect of crop production (Kasasian, 1971). Poor weed control is one of the major factors for yield reduction in rice (Amarjit et al, 1994). Weed can be controlled by mechanical means or chemical means. Mechanical weed control is expensive and chemical method leads to environmental pollution and in many weed species have developed resistance against the herbicides

II. Material and Methods

A field experiment entitled *"Effect of Planting Density and Weeding Regime on Yield Attributes and Yield of Drum Seeded Rice (Oryza sativa L.)"* was conducted at the Agricultural College Farm, Bapatla on sandy loam soil during *kharif* 2012. The treatments consisted of combination of five drum seeder spacings (20×7cm, 20×10.5cm, 20×14cm, 20×17.5cm, 20×24.5cm, and manual planting (20×15cm), with a rice plant density of 71, 47, 35, 28, 20 and 33 hills m^{-2}, respectively, and five weed management practices *viz.,* weedy check (W_1), hand weeding at 20 and 40 DAS (W_2), cono weeding twice at 20 and 40 DAS with modified cono weeder (W_3), pre-emergence application of anilofos @ 0.375 kg a.i ha^{-1} and post-emergence application of 2, 4 D salt @1.0 kg a.i ha^{-1} at 25 DAS (W_4), pre-emergence application of pendimethalin @1.0 kg a.i ha^{-1}post-emergence application of bispyribac sodium @ 20 g a.i ha^{-1} 30 DAS (W_5).

The trail was laid out in strip plot design and replicated thrice. The rice variety used was NLR - 33358 (*SOMASILA*). Fertilizer was applied at the rate of 120:60:60 N: P_2O_5:K_2O kg ha^{-1}. Nitrogen was applied in two split doses at time of tillering and panicle initiation stage along with basal dose. Phosphorus and potassium was applied as basal.

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Predominant weed flora of the experimental field:

BOTANICAL NAME	COMMON NAME	FAMILY	LIFE CYCLE
Grasses			
Echinochloa colona	Jungle rice	Poaceae	Annual
Echinochloa crusgalli	Awned barnyard grass	Poaceae	Annual
Cynodon dactylon	Bermuda grass	Poaceae	Perennial
Sedges			
Cyperus rotundus	Purple nut sedge	Cyperaceae	Perennial
Cyperus difformis	Umberella sedge	Cyperaceae	Annual
Fimbristylis miliacea	Hoorah grass	Cyperaceae	Annual
Broad leaf weeds			
Eclipta alba	False daisy	Asteraceae	Annual
Ludwigia parviflora	Winter primose	Onagraceae	Annual
Ammania baccifera	Red stem	Lathraceae	Annual
Euphorbia hirta	Garden spurge	Euphorbiaceae	Annual

Data collection of weeds:

Three weed samples per m^2were collected at the time of weeding. The quadrat was placed at random in the unit plot and all the weeds within each 1 m^2were uprooted, dried first in the sun and thereafter, for 24 hours in an electric oven maintaining a constant temperature of 70 ^{0}C. After drying weight of each sample were taken. The average weed dry weight was expressed in g m^{-2}.

Data collection of crop characters:

Data were collected from five hills per plot and then averaged. The panicles which had at least one grain were considered as effective tillers. Panicle length was recorded from the basal node of the rachis to the apex of each panicle. Grains lacking any food material inside were considered as unfilled grains and such grains present on the each tiller were counted. Presence of any food material in the grains was considered as filled grains and such grains presence on the each tiller was counted. Total number of grains from randomly selected five hills were counted and then averaged. One thousand clean dried grains were counted form the seed lot obtained from each plot and weighed by using an electric balance. Grains obtained from randomly selected five hills were sun dried and weighed carefully. Then it was averaged to get grain weight $hill^{-1}$. Straw obtained from randomly selected five sample hills of respective plot was dried in sun and weighed and then averaged. Grains obtained from each unit plot were sun dried and weighed carefully. The dry weights of grains from the panicle of the sample hills were added to the respective plot yield to record the grain yield $plot^{-1}$. Straw obtained from each unit plot including the straw of five sample hills of respective plot was dried in sun and weighed to record the straw yield $plot^{-1}$. The grain and straw yields per plot were subsequently converted to $ha^{-1}$and recorded. Data recorded for different crop parameters were compiled and tabulated in proper form for statistical analysis. The experimental data are statistically analyses by using Fisher's method of analysis of variance as outlined by Panse and Sukhatme (1978). Critical Difference (CD) was calculated wherever F-test was found significant. The level of significance used in F-test was five per cent.

III. Result and Discussion

Weed density

Weed density and weed drymatter production were significantly lower with plant density of 71hills m^{-2} as compared to other rice plant densities. Among weed management practices, the lowest weed density and weed drymatter production were recorded with cono weeding twice at 20 and 40 DAS (W_3) which was on a par with hand weeding twice at 20 and 40 DAS (W_2) at all stages of crop growth except at 20 DAS. Whereas the weedy check treatment registered the highest weed density and drymatter production over all other treatments. Similar results were observed by several researchers including Bhowmick *et al.* (2000) and Walia *et al.* (2008).

Interaction effect of weeding regime and planting density on weed density and dry matter:

A significant interaction between rice plant density and weed management practices showed that all the treatments were significantly superior over weedy check in reducing weed drymatter production at all the crop growth stages. However, W_2, W_3 or W_5 with higher rice plant densities performed excellently compared to other treatment combination. (Fig:1 and Fig:2)

Number of productive tillers m-2:

Effect of planting density:

Productive tillers per unit area were significantly increased with an increase in rice plant density with maximum number observed in 47 hills m^{-2} (D_2) followed by (D_1). Maximum productive tillers (279 m^{-2}) recorded with a plant density of 47 hills m^{-2} (D_2) were significantly higher compared to a plant density of 71 hills m^{-2} (D_1), 35 hills m^{-2} (D_3), 28 hills m^{-2} (D_4), 20 hills m^{-2} (D_5) and transplant (D_6) 233, 171, 149, 92 and 196 m^{-2}, respectivel (Table no.1). Lesser number of productive tillers in D_1 than D_2 may be due to inter or intra plant competition due to higher plant density leading to more mortality of normal tillers. Whereas, lesser number of productive tillers in D_3 to D_6 treatments compared to D_2 might be due to lesser number of normal tillers owing to reduced level of plant density.

Effect of weeding regime:

Among weed management practices, cono weeding twice at 20 and 40 DAS (W_3) recorded highest number of productive tillers (244 m^{-2}) and it was on a par with hand weeding twice at 20 and 40 DAS (W_2). Lowest number of productive tillers (119 m^{-2}) was recorded with weedy check (W_1) compared to other weed management practices. (Table no:1 and Fig: 3)

Interaction effect of weeding regime and planting density:

A significant interaction between rice plant densities and weed management practices showed that maximum productive tillers were observed in a combination of medium rice plant density of 47 hills m^{-2} (D_2) with W_3 (398 m^{-2}) followed by (359 m^{-2}) and W_5 (342 m^{-2}).

Panicle length:

Effect of planting density:

Panicle length progressively increased with decreasing plant density from71 hills m^{-2} to 20 hills m^{-2}. Highest panicle length (17.7 cm) was recorded with plant density (D_5) 20 hills m^{-2}. While lowest panicle length (15.2 cm) was recorded with highest plant density (D_1) 71 hills m^{-2}. The wider spacing in low plant density treatments proved to be specially advantageous for better development of panicles and 1000-grain weight. This might be due to the lesser inter and intra-plant competition at wider spacing as also reported by (Donald, 1963).

In addition, higher photosynthetic activity at lower to medium plant population might have enabled greater translocation of photosynthates in the sink and hence improvement in most of the yield attributes. These findings are in agreement with those reported by Balasubramaniyan and Palaniappan, 1991, Shiyas, 1992 and Rajarathinam and Balasubramaniyan, 1999. (Table no:1)

Effect of weeding regime:

Among weed control treatments W_3 recorded longer panicles (18.2 cm) followed by W_2. In fact all the weed control treatments resulted in significant lengthy panicle over weedy check (14.5cm). These results are in accordance with findings of Padmakanta Dhal and Gadhadhar Misra (1994).

Interaction effect of weeding regime and planting density:

A significant interaction between rice plant densities and weed management practices showed lengthy panicles (23.8 cm) in $D_1 \times W_4$. In nutshell there was a greater crop-weed competition in drum seeding as rice plants and weeds emerge simultaneously. However, puddling prior to soil in drum may control just emerged weeds and facilitate good establishment of rice seedlings.

This situation might have lead to increase in all the yield attributes as that of traditional transplant system. However, the weed menace associated with the direct seeding system could be overcome by sequential application of pre and post-emergence herbicides. While, considering the advantages of getting adequate plant population, desired crop geometry and easiness in weeding, placement of seeds by the drum seeder proved to be a better technology for direct seeding in rice in comparison to drilled sowing or even transplant. The results of present also proved the above hypothesis. (Fig:4)

Johnkutty *et al.* (2002) also indicated that the labour intensive and costly method of transplant could be substituted by direct seeding with no sacrifice in productivity, if effective weed control is undertaken.

Number of grains per panicle:

Effect of planting density:

Number of grains per panicle was higher (109) at the lowest rice plant density of 20 hills m^{-2} and it was significantly higher over the other four plant densities. The per cent increase in total number of grains per panicle in 20 hills m^{-2} treatment over 71 hills m^{-2}(D_1), 47 hills m^{-2}(D_2), 35 hills m^{-2}(D_3), 28 hills m^{-2} (D_4), 33 hills m^{-2}(D_6), was in the order of 30%, 20.1%, 12%, 11%, and 6% respectively. Lesser number of plants due to non existence of inter or intra plant competition helped in increasing the grain number with robust growth of panicle.

Effect of weeding regime:

Among weed management treatments, cono weeding twice (W_3) recorded significantly higher number of filled grains per panicle (133) over other treatments, indicated that weeding through cono weeder provided better micro atmosphere to enhance the panicle growth with more grains. By and large the variations among different treatments with respect to test weight were through significant but not so much numerically.

Thousand grain weight (g) (Test weight):

Effect of planting density:

The thousand grain weight significantly decreased with increasing plant densities. The highest test weight was recorded in D_5 treatment with 20 hills m^{-2} (20.3 g) as against the lowest test weight (18.6 g) in D_1 treatment with 71hills m^{-2}.

Effect of weeding regime:

With regard to weed management treatments, cono weeding twice (W_3) recorded significantly higher test weight (20.2 g) than other treatments except hand weeding (W_2) and pre-emergence application of pendimethalin followed by post-emergence application of bispyribac sodium (W_5). A significant interaction between rice plant densities and weed management practices showed a highest test weight of 21.0 g with a treatment combination of $D_5 \times W_3$ followed by 20.9 g in $D_6 \times W_3$.

Grain yield (kg ha-1)

Effect of planting density:

Among various rice plant densities, a medium level population of 47 hills $^{-2}$ (D_2) significantly increased the paddy over all other treatments except D_1 treatments with a plant density of 71 hills m^{-2} The highest grain yield of 3476 kg ha^{-1} was observed with a plant density of 47 hills m^{-2} and it was significantly superior to 35, 28, 20 drum seeded and 33 hills m^{-2} transplanting paddies. It was on a par with a grain yield of 3154 kg ha^{-1} in D_1. The manual transplant (D_6) gave yield of 3085 kg ha^{-1}which was on par with the plant density 71 and 35 hills m^{-2} drum seeded rice (D_3) with 3154 and 3060 kg ha^{-1} respectively. Mahajan *et.al.* (2010) also demonstrated that rice grain yield increased with an increase in plant density to a certain level, further increase of plant density beyond optimum level had a negative effect owing acute inter and intra plant competition for available resources.

A lower plant density of 28 and 20 hills m^{-2} in D_4 and D_5 treatments reduced the paddy in adequate special occupation for optimal utilization of in situ and externally applied resources there by negating the phenomenon law of constant described by Bond *et. al*. (2005).

Effect of weeding regime:

Among the weed management practices, significantly higher paddy grain yield (3747 kg ha^{-1}) as compared to all other weed management practices was recorded by twice cono weeding (W_3) which was on a par with twice manual weeding W_2 treatment with 3570 kg ha^{-1}. The significant lowest plant grain yield (1188 kg ha^{-1}) was recorded by the weedy check (W_1) treatment. Among chemical methods of weed management pre-emergence application of pendimethalin followed by post-emergence application of bispyribac sodium at 30 DAS (W_5) was found better in increasing the yield over the pre-emergence application of anilofos followed by post-emergence application of 2,4.D sodium salt (W_4). The increase in paddy grain yield cono weeding (W_2), hand weeding twice (W_3), application of and pendimethalin followed by bispyribac-sodium (W_5) and application of anilofos followed by 2,4 D sodium salt (W_4) over weedy check (W_1) was 67.4, 66.4, 63 and 56 per cent, respectively. Sequential application of pre-emergence followed by post-emergence herbicide proved better for prolonged period of controlling weeds to realise higher yields in rice. These results are in conformity with the finding of Bhowmick *et al*. (2000)

The superiority of weed control by cono weeder or manual means over remaining treatments might be due to effective control of weeds as well as providing congenial soil aeration which has helped in an increase in the yield attributes that ultimately led to higher paddy grain yield. Though controlling of weeds through chemicals is a cost effective approach, the results clearly indicated that the chemical control of weeds cannot be a substitute to either cono or hand weeding, as the yields obtained with herbicides was far lower than cono and hand weeding.

Mechanical weed control significantly increased grain yields. Weeder use alone increased the plant height and enhanced the grain yield as compared to manual weeding. The drymatter production during the growing season showed that the differences between the weed control treatments occurred primarily after flowering. The higher grain yield recorded in the use of mechanical weeder and continued stirring of soil could be attributed to prolonged active leaves leaf area index (LAI) and higher number of productive tillers.

Incorporation of weed with mechanical weeder increased the root activity which stimulated the new cell division in roots by pruning of some upper roots that encouraged deeper root growth thereby increased the shoot: root ratio (Uphoff, 2001). This was in accordance to the theory that partial excision of roots of wheat seedlings resulted in an increase in the growth rate of the remaining root system (Hunt, 1975, Vysotskaya *et al*. 2001). The capacity of the plant to absorb water and nutrients is closely related to the total length of the root system (Yoshida, 1981) which subsequently increases higher assimilation which will favor higher yield attributes and yield.

Interaction effect of weeding regime and planting density:

A significant interaction between rice plant densities and weed management practices showed that a treatment combination of $D_2 \times W_3$ gave the highest paddy grain yield of 4275 kg ha^{-1} which was significantly superior to all the treatment combination. Next best treatment combination is $D_2 \times W_2$ and $D_1 \times W_3$ with a grain yield of 4142 kg ha^{-1} and 4124 kg ha^{-1} and superior to all other treatment combination even when compared with transplanted paddy system. These results clearly showed that medium to slightly higher plant densities above 33 hills m^{-2} with a combination of weed management technique which will serve the dual purpose of controlling first and second generation of both grassy and broad leaved weeds with an added advantage of soil pulverisation to enhance intermittent aeration would be the better option to extract higher rice productivity through direct seeded method of drum seeding which was even better than the traditional system of transplanted paddies particularly under the situation of depleting manual labour scenario. (Fig : 6)

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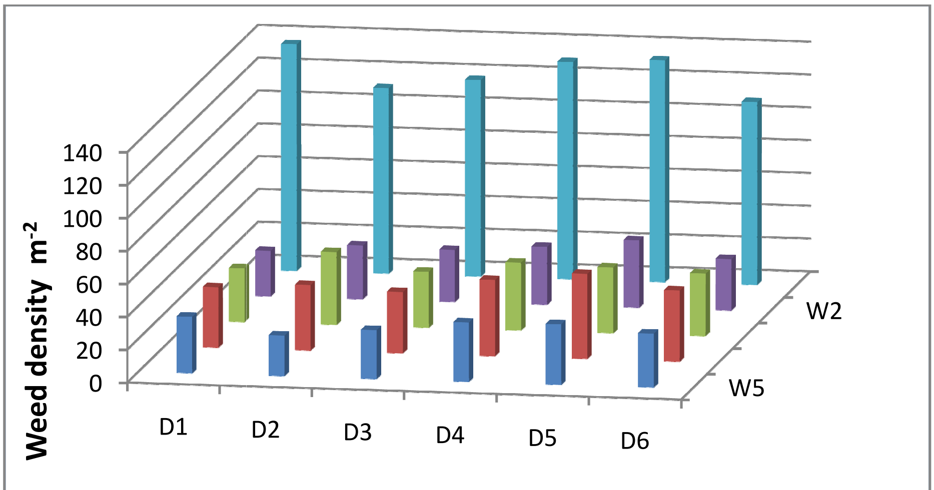
Table 1: Effect of weeding regime and planting density on yield attributes of drum seeded rice (Oryza sativa L.)

	TREATMENT	Weed density (m^{-2})	Weed Dry matter ($g\ m^{-2}$)	Number of productive tillers m^{-2}	panicle length (Cm)	Number of grains $panicle^{-1}$	Test weight (g) 1000 grain weight	Grain yield ($kg\ ha^{-1}$)
	PLANT DENSITY (D)							
D_1	**20 ×7cm (71 hills m^{-2})**	45.9	44.1	233	15.2	75.7	18.6	3154
D_2	**20 ×10.5cm (47 hills m^{-2})**	50.9	50.9	279	16.0	86.5	19.3	3476
D_3	**20 ×14cm (35 hills m^{-2})**	52.5	64.5	171	16.2	94.4	19.2	3060
D_4	**20 ×17.5cm (28hills m^{-2})**	58.3	67.6	149	16.7	96.6	19.8	2598
D_5	**20 ×24.5cm (20 hills m^{-2})**	60.9	81.9	92	17.7	108.9	20.3	2419
D_6	**Manual transplanting 20 ×15cm (33 hills m^{-2})**	51.3	62.5	196	17.2	101.7	19.8	3085
	SEm±	1.0	1.2	5	1.67	1.67	0.1	104
	CD (p = 0.05)	3.3	4.0	16	5.2	5.2	0.4	328
	CV (%)	7.6	8.0	6.7	7.4	7.4	2.9	14
	WEED MANAGEMENT (W)							
W_1	**Weedy check**	124.9	94.2	119	14.5	50.4	18.4	1188
W_2	**Hand weeding at 20 and 40 DAS**	33.3	54.0	235	17.2	114.9	19.9	3570
W_3	**Cono weeding at 20 and 40 DAS**	38.4	51.0	244	18.2	132.5	20.2	3747
W_4	**Anilofos @ 0.375 Kg a.i ha^{-1} (3-5 DAS) followed by 2, 4 D Salt 1.0 Kg a.i ha^{-1} at 20-25 DAS**	42.5	61.7	174	15.3	73.9	19.5	3004
W_5	**Pendimethalin @1.0 Kg a.i ha^{-1} (3-5 DAS) followed by Bispyribac Sodium @ 20 g a.i ha^{-1} 30 DAS**	32.3	50.5	212	16.4	103.1	20.0	3235
	SEm±	2.9	2.0	4	0.6	0.6	0.1	160
	CD (p = 0.05)	9.8	6.3	12	1.9	1.9	0.5	520
	CV (%)	23.0	13.6	15	2.9	2.9	3.6	23

	Interaction	Weed density W x C	Weed density C x W	Weed Dry matter W x C	Weed Dry matter C x W	Productive tillers W x C	Productive tillers C x W	Panicle length W x C	Panicle length C x W	Grains W x C	Grains C x W	Test weight W x C	Test weight C x W	Grain yield W x C	Grain yield C x W
	SEm±	3.7	2.9	9.2	2.6	78	9	7.2	2.5	7.2	2.5	0.3	0.2	18	14
	CD (p = 0.05)	10.8	9.0	27.1	8.0	230	27	21.5	7.4	21.5	7.4	0.6	NS	53	43
	CV (%)	7.0.		6.7		5.7		5.5		5.8		2.5		5.5	

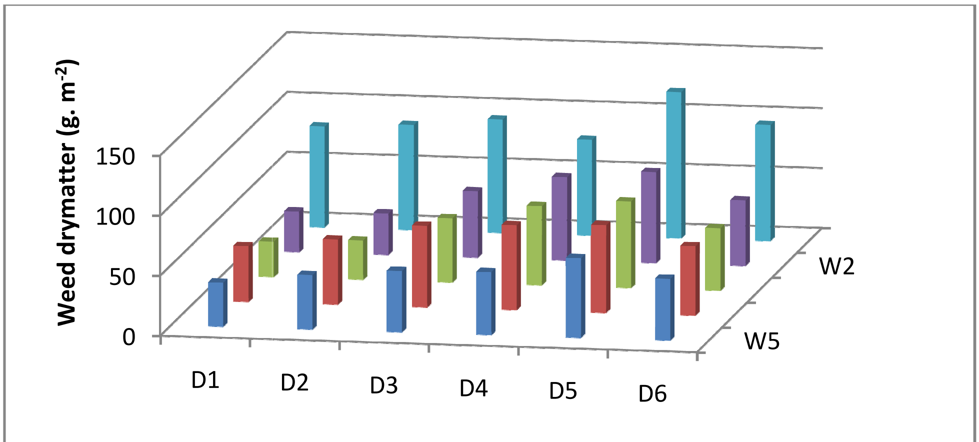
Note:
D×W=densities means at the same level of weed management means
W×D= weed management means at the same level of densities means



	D1	D2	D3	D4	D5	D6
W5	34.3	24.7	29.7	36	36.7	32.7
W4	36.7	39.7	37.3	46.3	51.7	43.3
W3	32.7	44.3	34	41.3	40	38
W2	27.7	32.7	31.7	35.3	41	31.3
W1	138	113	119.7	132.3	135	111.3

RICE PLANT DENSITIES(D) WEED MANAGEMENT PRACTICES(W)

Fig.1. Weed density at harvest as influenced by varied rice plant densities and weed management practices in drum seeded rice.



	D1	D2	D3	D4	D5	D6
W5	36.6	45.3	51	52.3	66.3	51.3
W4	46.4	54.2	68	70.7	73	57.8
W3	29.5	32.7	53.5	65.9	72.1	52.1
W2	33.9	34.6	55.3	69.4	75.9	54.6
W1	84.2	87.8	94.6	79.9	122	96.9

RICE PLANT DENSITIES(D) WEED MANAGEMENT PRACTICES(W)

Fig.2. Weed drymatter at harvest as influenced by varied rice plant densities and weed management practices in drum seeded rice

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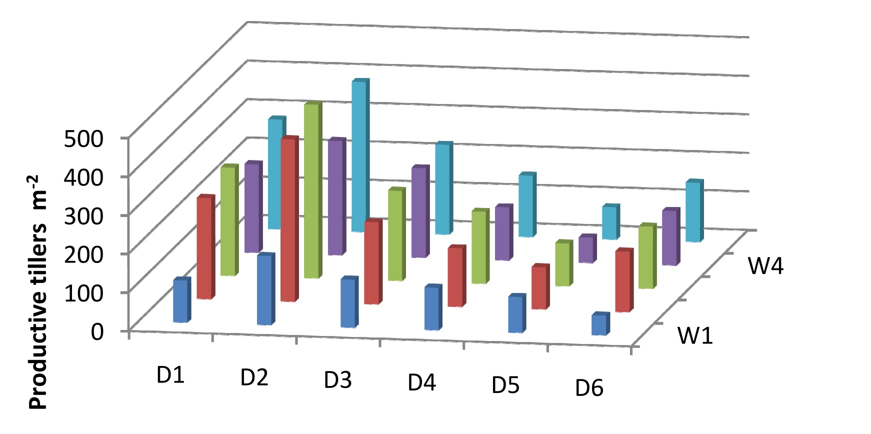
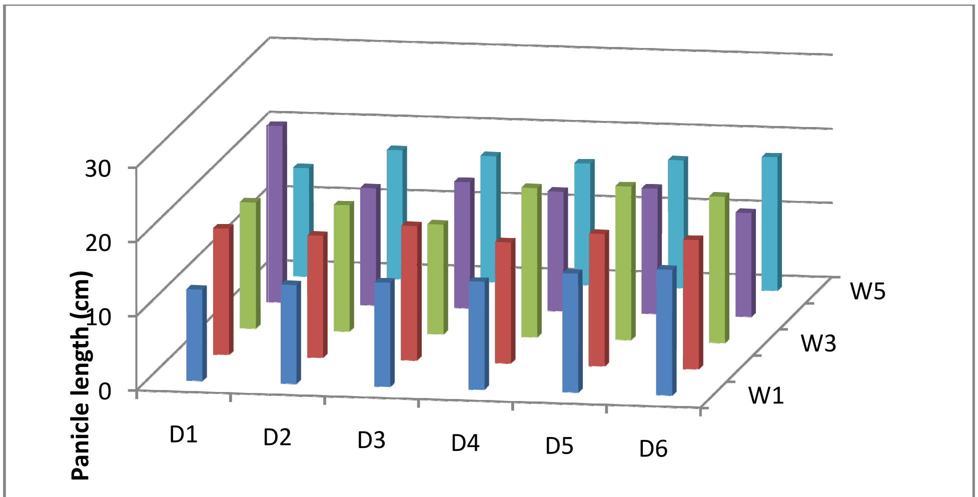


	D1	D2	D3	D4	D5	D6
W1	109	179	124	110	92	51
W2	262	421	212	152	109	157
W3	281	450	234	186	111	161
W4	229	296	232	137	65	141
W5	285	389	232	159	84	154

Fig.3. Rice productive tillers as influenced by varied rice plant densities and weed management practices in drum seeded rice



	D1	D2	D3	D4	D5	D6
W1	12.3	13.3	14	14.5	16	16.9
W2	17	16.4	18.1	16.3	17.8	17.4
W3	17	17	14.8	20.1	20.7	19.7
W4	23.8	15.8	17	16.1	16.9	14
W5	14.6	17.4	17	16.4	17.2	18

Fig.4. Rice panicle length as influenced by varied rice plant densities and weed management practices in drum seeded rice

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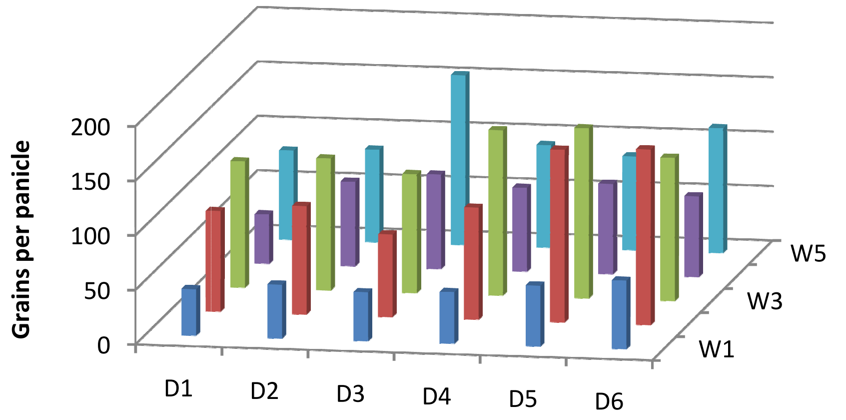
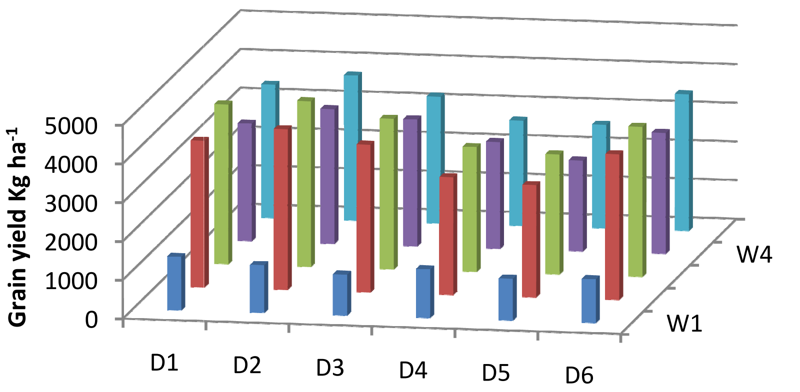


	D1	D2	D3	D4	D5	D6
W1	42.7	49.3	44.7	47.3	55.7	62.7
W2	92.3	99.3	75.7	102.7	158.3	161
W3	116	121	109	151.7	156	131.3
W4	45.3	77.7	86.7	77	83	74
W5	82	85.3	156	94.3	86.3	114.7

RICE PLANT DENSITIES (D)

WEED MANAGEMENT PRACTICES(W)

Fig.5. Grains per panicle as influenced by varied rice plant densities and weed management practices in drum seeded rice



	D1	D2	D3	D4	D5	D6
W1	1378	1230	1054	1256	1078	1133
W2	3779	4142	3811	3034	2897	3759
W3	4124	4275	3887	3224	3098	3875
W4	3038	3478	3277	2759	2345	3124
W5	3451	3755	3273	2719	2675	3534

RICE PLANT DENSITIES(D)

WEED MANAGEMENT PRACTICES(W)

Fig.6. Grain yield as influenced by varied rice plant densities and weed management practices in drum seeded rice