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Critical agronomic interventions for enhancing productivity of dry direct sown rice in North-Coastal AP

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Abstract
A field experiment on dry direct sown rice was conducted during *kharif*, 2018 and 2019 at the Agricultural College Farm, Naira, Srikakulam of North-Coastal zone of A.P to study the influence of weed control methods, nutrient management practices and micronutrients application on growth and yield. Remarkable effects were noticed on growth and yield components *viz.*, plant height, productive tillers m^{-2}, grain and straw yield of rice. Various weed management treatments significantly decreased the population and dry weight of weed and increased the crop growth characters and yield when compared to weedy check. Among weed control methods, sequential application of pyrazosulfuron ethyl *fb.*florpyrauxifen-benzyl registered taller plants, higher number of productive tillers m^{-2}, higher grain and straw yield which was however, found parity with bispyribac sodium *fb.* 2,4-D amine salt + fenoxyprop-ethyl with safener. Among nutrient management practices, application of 100% RDF produced tallest plants as well as higher yields. Basal application of $ZnSO_4$ @ 50 kg ha^{-1} outperformed other micronutrient management practices.

Keywords: critical agronomic interventions, dry direct sown rice, North-Coastal AP

Introduction
Direct Seeding of Rice (DSR) refers to the process of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery (Farooq *et al*., 2011) [4]. Weed control is more difficult in dry-DSR (Direct seeded rice) than CT-TPR (Conventional puddle transplanting) because of simultaneous emergence rice seedlings with weeds in dry–DSR which are less competitive than 30-35 days old rice seedlings use in CT- TPR. Initial flooding used in CT-TPR is effective for weed control but it is not same in dry-DSR as in this system, the early growth of rice, up to 30-40 days is in a dry soil environment and thereafter the field gets submerged with the release of canal water. The absence of stagnant water during the initial 4-6 weeks causes serious weed problems in dry sown rice and poses challenge to weed management (Rao *et al.,* 2007) [14]. Advancement of research in herbicide technology opened a new vista that has led to identification of several low dose high efficiency broad spectrum herbicides which paved the way for the farmers to shift from conventional transplanting to DSR culture. Therefore, considering the emergence of diverse weed flora in *kharif* season, the purpose cannot be solved by one-time application of herbicide alone. Under this back drop, there is every need to apply more than one herbicide in combination or in sequence, which can offer greater promise in managing complex and diverse weed flora in DSR (Raj *et al.,* 2013) [12]. Nutrient management plays an important role in optimization of crop yields. Among different nutrients, nitrogen being the most important, the efficacy of which depends amongst others, the crop-weed dynamics in the growing ecosystem. Micronutrients are as important as macronutrients and involved in vital metabolic events in the plants. Deficiency of even a single essential micronutrient may disturb the plant developmental cascades and cause substantial reduction in crop yield (Tripathi *et al.,* 2015) [20]. In direct seeding, availability of several nutrients including N, P, K and micronutrients such as Zn and Fe are reported to be a constraint in realization of production potential of rice. Micronutrients, particularly zinc and iron have attained a great significance in today's intensive and exploitive agriculture which is

aiming at higher crop productivity.

Materials and methods

A field experiment was conducted during kharif season of 2018 and 2019 at Agricultural College Farm, Naira, Srikakulam, Andhra Pradesh. The soil was Sandy clay loam in texture, alkaline in reaction, low in organic carbon and available nitrogen and medium in available phosphorus and available potassium. The experiment was laid out in split-split plot design with three replications. The weed management subjected to main plots, nutrient management in sub plots while, application of micronutrients to sub-sub plots. Experiment was comprised of four weed control methods, *viz.,* W_1: Unweeded check, W_2: Hand weeding twice at 20 and 40 DAS, W_3: Pyrazosulfuron ethyl @ 20 g a.i ha^{-1} at 8-12 DAS *fb.*florpyrauxifen-benzyl @ 31.25 g a.i ha^{-1} at 25 DAS and W_4: Bispyribac sodium @ 150 g a.i ha^{-1} at 20 DAS *fb.* 2,4-D amine salt @ 600 g a.i ha^{-1} + fenoxyprop-ethyl with safener @ 150 g a.i ha^{-1} at 40-45 DAS, four nutrient management practices, *viz.,* N_1: Foliar application of 19-19-19 @ 1% at 20 DAS and 2% at 40 DAS *fb.*75% RDF from conversion onwards in three splits, N_2: Foliar application of 19-19-19 @ 1% at 20 DAS and KNO_3 @ 2% at 40 DAS *fb.*75% RDF from conversion onwards in three splits, N_3: 100% RDF (Entire P through SSP, ⅓rd N and ½ K as basal and remaining N and K through top dressing as per recommendation) and N_4: Farmers practice and three micronutrients application *viz.,* M_1: $ZnSO_4$ @ 50 kg ha^{-1}, M_2: Foliar application of $ZnSO_4$ @ 0.2% twice at 20 and 40 DAS and M_3: Foliar application of $ZnSO_4$ @ 0.2% and $FeSO_4$ @ 0.5% each at 20 and 40 DAS. 'MTU-1001' variety of rice was used for seeding of rice. The total rainfall received during crop season was 1001 and 1070 mm during first and second year, respectively. The required quantity of pre-emergence and post-emergence herbicides as well as major and micronutrients were sprayed as per treatment with the help of knap sack sprayer fitted with flat nozzle. The data on weeds were subjected to square-root transformation ($\sqrt{x}$ +0.5) to normalize their distribution.

Results and discussion

Effect on weed

The dominant weed species observed in the experimental field were *Echinochloa colona* (L.) Link. and *Echinochloa crus-galli* (L.) Link. among grasses, *Cyperus rotundus* L. among sedges and *Eclipta alba* (L.) Hassk and *Ludwigia parviflora* L. among broad leaved weeds were dominant throughout the crop growth period. Ramana *et al.* (2007) [13] also reported similar weed flora under deficit moisture conditions in rice cultivation.

Total weed density

A gradual and progressive increase in the total weed population was noticed at all stages of sampling during both the years of study. All the weed management practices were found to reduce total weed density over weedy check. At 60 DAS and at harvest, significantly lesser total weed density was noticed due to application of bispyribac sodium *fb.* 2,4-D amine salt + fenoxyprop-ethyl with safener which was however, comparable with pyrazosulfuron ethyl *fb.* florpyrauxifen-benzyl and hand weeding twice, where application of bispyribac sodium *fb.* 2,4-D amine salt + fenoxyprop-ethyl with safener was in turn on a par with hand weeding twice. Application of bispyribac sodium *fb.* 2,4-D amine salt + fenoxyprop-ethyl with safener could result in comparable performance to that of pyrazosulfuron ethyl *fb.* florpyrauxifen-benzyl in suppression of total weed population which involves application of three herbicides in a row at 20 days interval and both were found parity with hand weeding twice. Better performance of pyrazosulfuron, pendimethalin, flufenacet and bispyribac in reducing total weed density has also been reported by Kumar *et al.* (2013) [6], Rawat *et al.* (2012) [15].

Nutrient management practices were found to influence total weed density to a statistically measurable magnitude. Significantly lower total weed density was noticed with farmers practice which was however, on a par with foliar application of 19-19-19 and KNO_3 *fb.* 75% RDF and foliar application of 19-19-19 twice *fb.* 75% RDF. Application of 100% RDF registered the highest total weed density among the nutrient management practices. It might be due to better competitive ability of weeds to enjoy the 1/3rd of the nitrogen applied as basal at the time of sowing to record the highest total weed density. These results are in conformity with the findings of Chaudhary *et al.* (2011) [2].

As regards application of micronutrients, significantly lower total weed density was observed in plots which received foliar $ZnSO_4$ and $FeSO_4$ which was however, comparable with foliar feeding of $ZnSO_4$ twice during both the years of investigation and pooled mean. Basal application of $ZnSO_4$ @ 50 kg ha^{-1} registered maximum total weed density at all sampling intervals during successive years and pooled mean. Basal dressing of $ZnSO_4$ might have provided early opportunity for the growth of weeds over other two micronutrient management practices where, the micro nutrients are supplied at later stage through foliage, leaving negligible amounts available to the weeds growing underneath for their absorption.

Table 1: Total weed density (No.m^{-2}) and weed dry matter production (kg ha^{-1}) at 60 DAS as influenced by weed control methods, nutrient management practices and application of micronutrients to dry direct sown rice

Treatments	Total weed density (No.m^{-2})			Total weed drymatter (kg ha^{-1})		
	2018	2019	Pooled	2018	2019	Pooled
Weed Control Methods (W)						
W_1: Unweeded check	17.69 (313.3)	18.21 (331.9)	17.95 (322.6)	14.48 (211.4)	14.68 (217.2)	14.58 (213.5)
W_2: Hand weeding twice at 20 and 40 DAS	13.03 (170.8)	13.74 (188.8)	13.40 (179.8)	9.30 (87.2)	9.92 (99.7)	9.63 (93.1)
W_3: Pyrazosulfuron ethyl @ 20 g a.i ha^{-1} at 8-12 DAS *fb.* florpyrauxifen-benzyl @ 31.25 g a.i ha^{-1} at 25 DAS	12.70 (161.5)	13.62 (185.5)	13.17 (173.5)	8.77 (76.9)	9.28 (85.8)	9.03 (81.4)
W_4: Bispyribac sodium @ 150 g a.i ha^{-1} at 20 DAS *fb.* 2,4-D amine salt @ 600 g a.i ha^{-1} + fenoxyprop-ethyl with safener @ 150 g a.i ha^{-1} at 40-45 DAS	12.54 (157.6)	13.24 (178.6)	12.90 (166.7)	8.82 (77.6)	9.20 (84.3)	9.01 (81.1)
SEm ±	0.24	0.18	0.30	0.10	0.14	0.16
CD (P = 0.05)	0.82	0.63	1.03	0.34	0.47	0.54

CV (%)	10.22	7.44	12.50	5.62	7.57	8.94
Nutrient Management Practices (N)						
N_1: Foliar application of 19-19-19 @ 1% at 20 DAS and 2% at 40 DAS *fb.* 75% RDF from conversion onwards in three splits	13.85 (197.6)	14.74 (221.4)	14.31 (209.5)	10.18 (108.5)	10.70 (118.3)	10.45 (112.6)
N_2: Foliar application of 19-19-19 @ 1% at 20 DAS and KNO_3 @ 2% at 40 DAS *fb.* 75% RDF from conversion onwards in three splits	13.90 (197.2)	14.55 (215.6)	14.23 (206.4)	10.07 (108.1)	10.69 (120.2)	10.39 (114.2)
N_3: 100% RDF (Entire P through SSP, ⅓rd N and ½ K as basal and remaining N and K through top dressing as per recommendation)	14.75 (222.5)	15.38 (240.9)	15.07 (231.7)	10.61 (119.4)	10.88 (124.8)	10.75 (122.2)
N_4: Farmers practice (Entire P, ½ N and K immediately after conversion, remaining N and K at PI stage)	13.48 (185.9)	14.15 (206.9)	13.82 (195.0)	10.51 (117.0)	10.80 (123.6)	10.66 (120.1)
SEm ±	0.16	0.13	0.13	0.04	0.05	0.07
CD (P = 0.05)	0.46	0.38	0.38	0.10	0.15	0.20
CV (%)	6.79	5.34	5.43	2.04	2.82	3.97
Micronutrients (M)						
M_1: $ZnSO_4$ @ 50 kg ha^{-1}	14.48 (214.0)	15.04 (232.8)	14.77 (222.4)	10.94 (127.0)	11.44 (137.4)	11.19 (132.0)
M_2: Foliar application of $ZnSO_4$ @ 0.2% twice at 20 and 40 DAS	13.82 (195.5)	14.59 (216.8)	14.21 (206.1)	10.20 (110.1)	10.69 (119.6)	10.45 (114.5)
M_3: Foliar application of $ZnSO_4$ @ 0.2% and $FeSO_4$ @ 0.5% each at 20 and 40 DAS	13.68 (192.8)	14.48 (214.0)	14.10 (203.4)	9.89 (102.7)	10.18 (108.3)	10.04 (105.3)
SEm ±	0.14	0.11	0.14	0.02	0.04	0.06
CD (P = 0.05)	0.41	0.31	0.39	0.05	0.12	0.18
CV (%)	7.10	5.09	6.58	1.09	2.83	4.16
Interaction						
WXN						
SEm ±	0.32	0.26	0.26	0.07	0.10	0.14
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
WXM						
SEm ±	0.29	0.22	0.27	0.03	0.09	0.13
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
NXM						
SEm ±	0.29	0.22	0.27	0.03	0.09	0.13
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
WXNXM						
SEm ±	0.57	0.43	0.55	0.07	0.18	0.25
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Data were subjected to square root transformation $\sqrt{x}$ +0.5. Figures in parenthesis are original values

Total weed drymatter

There was a gradual and progressive increase in total weed drymatter production between any two sampling intervals till harvest. Application of pyrazosulfuron ethyl *fb.* florpyrauxifen-benzyl registered significantly lower total weed drymatter which was however, on a par with bispyribac sodium *fb.* 2,4-D amine salt + fenoxyprop-ethyl with safener and hand weeding twice at critical periods. Kutikuppala and Yashwant Singh, (2018) [7] also reported the effectiveness of pre-emergence application of pyrazosulfuron in controlling growth of weeds during initial stage, while post-emergence application of bispyribac checked the subsequent flushes during critical period of crop-weed competition.

Application of 100% RDF registered significantly larger total weed drymatter production at all the stages of sampling which was however, found parity with farmers practice at 60 DAS and foliar application of 19-19-19 and KNO_3 *fb.*75% RDF and foliar application of 19-19-19 twice *fb.* 75% RDF at harvest. While, farmers practice recorded significantly lesser total weed drymatter production. Significantly large weed drymatter due to application of 100% RDF might be due to favourable nutrition enjoyed by weeds right from the beginning of emergence as it was supplied through basal dressing. The innate ability of the weeds to absorb higher quantities of nutrients than the crop plants might have given an edge in this regard. Similar finding were reported by Devi and Singh (2018) [3] and Sharma *et al*. (2007) [17].

At all the stages of sampling, foliar application of $ZnSO_4$ and $FeSO_4$ recorded significantly lesser total weed drymatter production. While, the total drymatter production was found to be the highest due to application of $ZnSO_4$ @ 50 kg ha^{-1} as basal during both the years of study and pooled mean. It might be due to favourable nutrient pool created in the eco-rhizosphere to enable weed flora to absorb liberal quantities of essential nutrients by virtue of their competitive ability to accumulate large dry matter.

Effect on crop

Significantly taller plants were observed in plots which received pyrazosulfuron ethyl *fb.* florpyrauxifen-benzyl which was however, found parity with bispyribac sodium *fb.* 2,4-D amine salt + fenoxyprop-ethyl with safener at all the sampling intervals in both the years and pooled mean. Shortest plants were noticed in the plots which were unweeded throughout. Significantly taller plants observed due to sequential application of herbicides might be due to prolonged suppressive effect of herbicides on the growth of weeds and created better weed free environment to make the growth resources available to the advantage of crop plants for rapid cell division and elongation of internodal elongation. Enhanced growth parameters due to efficient weed control have been an undisputed fact as could be visualized from widely documented research evidence (Saravanane *et al.* 2016) [16].

Significantly taller plants were produced with 100% RDF while, the differences in plant height among 100% RDF, foliar application of 19-19-19 twice *fb.*75% RDF and foliar application of 19-19-19 and KNO_3 *fb.*75% RDF were found on a par with each other and significantly superior to farmers practice. Basal application of 1/3rd nitrogen of the 100% RDF might have given quick start and early lead at tillering to sustain in the early phase. Increase in plant height with increasing nutrient levels has been reported by Parashivamurthy *et al.* (2012) [11].

Application of $ZnSO_4$ @ 50 kg ha^{-1} produced significantly taller plants and comparable with foliar feeding of $ZnSO_4$ twice. Significantly shorter plants were found in plots which received $ZnSO_4$ and $FeSO_4$ through foliar feeding. Basal $ZnSO_4$ might have created a favourable nutrio-physiology right from beginning of crop growth resulted in producing taller plants compared to rest of the treatments. Adequate Zn nutrition is essential for meristamatic activity due to enhanced levels of auxins for which Zn remains as a precursor. The results are in agreement with those reported by Humaira *et al.* (2015) [5].

Larger number of productive tillers m^{-2} was produced with pyrazosulfuron ethyl *fb*.florpyrauxifen-benzyl which was however, found parity with bispyribac sodium *fb.* 2,4-D amine salt + fenoxyprop-ethyl with safener which in turn found on a par with hand weeding twice during both the years of study and pooled mean. Minimum number of productive tillers m^{-2} was observed in weedy check. Continuous and heavy robbing of nutrients in weedy check plots might have reduced total number of tillers and their subsequent conversion to productive tillers (Neeshu Joshi *et al.* 2015) [10].

Significantly higher number of productive tillers m^{-2} were noticed with 100% RDF which was however, comparable with foliar application of 19-19-19 twice *fb*.75% RDF and foliar application of 19-19-19 and KNO_3 *fb*.75% RDF. Higher number of productive tillers m^{-2} could be attributed to the fact that the regular supply of nutrients especially, nitrogen either as basal or foliage might have enabled accumulation of required levels of tissue nitrogen in rice to produce ample amounts of photosynthates to support the total tillers to get converted to productive tillers with advancement of age. The productive tiller number m^{-2} was minimum with farmers practice. The findings obtained in the present study also in agreement with the findings of several fellow agronomists (Srinivasagam and Stephan, 2013) [19].

Micronutrient management practices were found to influence the productive tiller number m^{-2} of rice to a statistically perceptible level. Basal application of $ZnSO_4$ @ 50 kg ha^{-1} produced significantly higher numbers of productive tillers m^{-2} which was however, found parity with foliar application of $ZnSO_4$ twice during both the years and pooled mean. Foliar application of $ZnSO_4$ and $FeSO_4$ resulted in significantly lesser number of productive tillers m^{-2}. Significantly large number of productive tillers might be due to improved metabolic activity with Zn that enhanced the floral primordial development in many tillers.

Table 2: Plant height (cm) and number of productive tillers m^{-2} of dry direct sown rice at harvest as influenced by weed control methods, nutrient management practices and application of micronutrients

Treatments	Plant height (cm)			Number of productive tillers m^{-2}		
	2018	2019	Pooled	2018	2019	Pooled
Weed Control Methods (W)						
W_1: Unweeded check	83.20	80.11	81.65	305	298	302
W_2: Hand weeding twice at 20 and 40 DAS	98.14	94.50	96.32	413	404	408
W_3: Pyrazosulfuron ethyl @ 20 g a.i ha^{-1} at 8-12 DAS *fb.* florpyrauxifen-benzyl @ 31.25 g a.i ha^{-1} at 25 DAS	108.41	104.45	106.43	460	450	455
W_4: Bispyribac sodium @ 150 g a.i ha^{-1} at 20 DAS *fb.* 2,4-D amine salt @ 600 g a.i ha^{-1} + fenoxyprop-ethyl with safener @ 150 g a.i ha^{-1} at 40-45 DAS	102.55	98.76	100.66	436	427	431
SEm ±	2.02	1.84	1.84	7.21	7.44	7.35
CD (P = 0.05)	6.99	6.37	6.37	24.96	25.74	25.45
CV (%)	12.37	11.70	11.47	10.72	11.31	11.05
Nutrient Management Practices (N)						
N_1: Foliar application of 19-19-19 @ 1% at 20 DAS and 2% at 40 DAS *fb.* 75% RDF from conversion onwards in three splits	102.47	98.68	100.57	415	406	411
N_2: Foliar application of 19-19-19 @ 1% at 20 DAS and KNO_3 @ 2% at 40 DAS *fb.* 75% RDF from conversion onwards in three splits	101.98	98.22	100.10	413	404	409
N_3: 100% RDF (Entire P through SSP, ⅓rd N and ½ K as basal and remaining N and K through top dressing as per recommendation)	103.75	99.92	101.83	421	412	416
N_4: Farmers practice (Entire P, ½ N and K immediately after conversion, remaining N and K at PI stage)	84.11	81.00	82.55	365	357	361
SEm ±	0.90	0.69	1.39	4.71	3.87	3.74
CD (P = 0.05)	2.62	2.02	4.06	13.75	11.30	10.91
CV (%)	5.49	4.40	8.68	7.00	5.89	5.62
Micronutrients (M)						
M_1: $ZnSO_4$ @ 50 kg ha^{-1}	100.13	96.43	98.28	410	401	406
M_2: Foliar application of $ZnSO_4$ @ 0.2% twice at 20 and 40 DAS	98.91	95.27	97.09	406	398	402
M_3: Foliar application of $ZnSO_4$ @ 0.2% and $FeSO_4$ @ 0.5% each at 20 and 40 DAS	95.20	91.66	93.43	394	385	390
SEm ±	0.67	0.36	0.99	3.06	1.65	1.80
CD (P = 0.05)	1.88	1.03	2.81	8.63	4.65	5.07
CV (%)	4.71	2.68	7.16	5.25	2.89	3.12
Interaction						
WXN						
SEm ±	1.79	1.39	2.78	9.42	7.75	7.48
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
WXM						

SEm ±	1.33	0.73	1.99	6.11	3.29	3.59
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
NXM						
SEm ±	1.33	0.73	1.99	6.11	3.29	3.59
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
WXNXM						
SEm ±	2.67	1.46	3.98	12.22	6.59	7.18
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Significant disparities in the grain and straw yield of rice was observed due to weed control methods and application of major and micronutrients. However, the interaction effects among main plot, sub-plot and sub-sub-plot treatments were not statistically measurable. Significantly higher grain and straw yield of rice was recorded in the plots which received pyrazosulfuron ethyl *fb.*florpyrauxifen-benzyl which was however, comparable with bispyribac sodium *fb.* 2,4-D amine salt + fenoxyprop-ethyl with safener and significantly superior to weedy check (W_1) during both the years of study and pooled mean. Uncontrolled weed growth in dry direct seeded rice was found to reduce the mean grain and straw yield to the tune of 67.48% and 31.79%, respectively indicating the adverse impact of weed flora on grain yield of rice. Detrimental effect of sequential application of herbicides on weed growth and the resultant enhancement of grain yield of rice might be due to initial competition offered by weeds up to 20 DAS and the subsequent flushes of weeds after first weeding till the second weeding was carried out at 40 DAS in hand weeding treatment. Similar views were also expressed by Chandra Prakash *et al.* (2013) [1] and Singh and Singh (2010) [18].

Application of 100% RDF registered significantly higher grain and straw yield which was however, found parity with foliar application of 19-19-19 twice *fb.*75% RDF and foliar application of 19-19-19 and KNO_3 *fb.*75% RDF during successive years of experimentation and pooled mean. The higher grain and straw yield obtained with 100% RDF could be attributed to the favourable influence of steady, consistent and adequate availability of nutrients during the required stages of crop growth, favouring the production of photosynthates coupled with better partitioning to the sink, under higher level of nutrition. These results are in conformity with findings of Malla Reddy *et al.* (2012) [8]. The grain yield associated with Farmers practice was found to be the lowest and inferior to rest of the nutrient management practices.

Significant disparities were found to be statistically perceptible with regard to application of micronutrients. Maximum grain yield was realized with basal application of $ZnSo_4$ @ 50 kg ha^{-1} which was however, comparable with foliar feeding of $ZnSO_4$ twice. While, the grain and straw yields realized with foliar application of $ZnSO_4$ and $FeSO_4$ was found to be minimum during both the years of study and pooled mean. Significantly higher grain yield associated with Soil or foliar application of $ZnSO_4$ could be attributed to improved growth and yield parameters through adequate availability of nutrients which in turn might have favourably influenced physiological processes and build up of photosynthates. These results were conformity with those of Meena and Fathima (2017) [9].

From the present investigation, it could be concluded that sequential application of pyrazosulfuron ethyl @ 20 g a.i ha^{-1} at 8-12 DAS *fb.*florpyrauxifen-benzyl @ 31.25 g a.i ha^{-1} at 25 DAS along with application of 100% RDF and basal application of $ZnSO_4$ @ 50 kg ha^{-1} was found to be the best package for realization of higher yield from dry direct sown rice in North-coastal A.P

Table 3: Grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of dry direct sown rice as influenced by weed control methods, nutrient management practices and application of micronutrients

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
	2018	2019	Pooled	2018	2019	Pooled
Weed Control Methods (W)						
W_1: Unweeded check	4023	3936	3979	5905	5538	5721
W_2: Hand weeding twice at 20 and 40 DAS	5328	5107	5218	6965	6458	6712
W_3: Pyrazosulfuron ethyl @ 20 g a.i ha^{-1} at 8-12 DAS *fb.* florpyrauxifen-benzyl @ 31.25 g a.i ha^{-1} at 25 DAS	6055	5737	5896	7780	7300	7540
W_4: Bispyribac sodium @ 150 g a.i ha^{-1} at 20 DAS *fb.* 2,4-D amine salt @ 600 g a.i ha^{-1} + fenoxyprop-ethyl with safener @ 150 g a.i ha^{-1} at 40-45 DAS	5733	5435	5584	7441	6980	7211
SEm ±	113.93	92.72	97.03	136.28	149.95	123.50
CD (P = 0.05)	394.26	320.86	335.77	471.60	518.90	427.37
CV (%)	12.66	10.98	11.13	11.61	13.62	10.86
Nutrient Management Practices (N)						
N_1: Foliar application of 19-19-19 @ 1% at 20 DAS and 2% at 40 DAS *fb.* 75% RDF from conversion onwards in three splits	5554	5210	5382	7243	6794	7018
N_2: Foliar application of 19-19-19 @ 1% at 20 DAS and KNO_3 @ 2% at 40 DAS *fb.* 75% RDF from conversion onwards in three splits	5527	5185	5356	7206	6760	6983
N_3: 100% RDF (Entire P through SSP, ⅓rd N and ½ K as basal and remaining N and K through top dressing as per recommendation)	5626	5277	5452	7341	6886	7113
N_4 : Farmers practice (Entire P, ½ N and K immediately after conversion, remaining N and K at PI stage)	4892	4590	4741	6383	5987	6185
SEm ±	61.56	35.89	63.92	61.76	71.97	53.46
CD (P = 0.05)	179.68	104.76	186.57	180.28	210.08	156.04
CV (%)	6.84	4.25	7.33	5.26	6.54	4.70
Micronutrients (M)						
M_1: $ZnSO_4$ @ 50 kg ha^{-1}	5550	5181	5366	7175	6730	6952

M_2: Foliar application of $ZnSO_4$ @ 0.2% twice at 20 and 40 DAS	5446	5109	5277	7126	6684	6905
M_3: Foliar application of $ZnSO_4$ @ 0.2% and $FeSO_4$ @ 0.5% each at 20 and 40 DAS	5204	4907	5056	6828	6406	6617
SEm ±	46.28	26.61	48.85	55.79	70.90	41.87
CD (P = 0.05)	130.76	75.17	138.02	157.61	200.31	118.30
CV (%)	5.94	3.64	6.47	5.49	7.43	4.25
Interaction						
WXN						
SEm ±	123.12	71.78	127.84	123.53	143.95	106.92
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
WXM						
SEm ±	92.57	53.21	97.70	111.57	141.80	83.75
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
NXM						
SEm ±	92.57	53.21	97.70	111.57	141.80	83.75
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
WXNXM						
SEm ±	185.14	106.43	195.41	223.15	283.60	167.50
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

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