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. florypyrazifen-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 ZnSO₄ @ 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 practices were applied in sub plots while, application of micronutrients to sub-sub plots. The experiment was comprised of four weed control methods, viz., W1: Unweeded check, W2: Hand weeding twice at 20 and 40 DAS, W3: Pyrazosulfuron ethyl @ 20 g a.i ha\(^{-1}\) at 8-12 DAS \(\text{fb.} \) flopyrauxifen-benzyl @ 31.25 g a.i ha\(^{-1}\) at 25 DAS and W4: Bispyribac sodium @ 150 g a.i ha\(^{-1}\) at 20 DAS \(\text{fb.} \) 2,4-D amine salt @ 600 g a.i ha\(^{-1}\) + fenoxprop-ethyl with safener @ 150 g a.i ha\(^{-1}\) at 40-45 DAS, four nutrient management practices, viz., N1: Foliar application of 19-19-19 @ 1% at 20 DAS and 2% at 40 DAS \(\text{fb.} \) 75% RDF from conversion onwards in three splits, N2: Foliar application of 19-19-19 @ 1% at 20 DAS and KNO\(_3\) @ 2% at 40 DAS \(\text{fb.} \) 75% RDF from conversion onwards in three splits, N3: 100% RDF (Entire P through SSP, \(\frac{1}{3}\) N and \(\frac{1}{2}\) K as basal and remaining N and K through top dressing as per recommendation) and N4: Farmers practice and three micronutrients application viz., M1: ZnSO\(_4\) @ 50 kg ha\(^{-1}\), M2: Foliar application of ZnSO\(_4\) @ 0.2% twice at 20 and 40 DAS and M3: Foliar application of ZnSO\(_4\) @ 0.2% and FeSO\(_4\) @ 0.5% each at 20 and 40 DAS. 'MTU-1001' variety of rice was applied as basal at the time of sowing to record the highest total weed density among the weed management practices. At 60 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) \(^{[8]}\), Rawat et al. (2012) \(^{[13]}\).

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\(_3\) \(\text{fb.} \) 75% RDF and foliar application of 19-19-19 twice \(\text{fb.} \) 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 \(\frac{1}{3}\)rd 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.

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.

### 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 direct sown rice

| Treatments | Total weed density (No.m\(^{-2}\)) | Total weed dry matter (kg ha\(^{-1}\)) |
|------------|----------------------------------|-------------------------------------|
|            | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled |
| Weed Control Methods (W) | | | | | | | | | |
| W1: 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) | 76.8 (161.4) | 85.8 (178.8) | 87.2 (180.5) | 9.03 (192.8) | 9.03 (193.1) | 9.03 (193.1) |
| W2: 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) | 87.6 (176.1) | 95.7 (188.5) | 97.7 (190.2) | 92.8 (195.8) | 92.8 (195.8) | 92.8 (195.8) |
| W3: Pyrazosulfuron ethyl @ 20 g a.i ha\(^{-1}\) at 8-12 DAS \(\text{fb.} \) flopyrauxifen-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) | 76.9 (166.7) | 84.3 (186.7) | 88.7 (192.8) | 90.1 (196.8) | 90.1 (196.8) | 90.1 (196.8) |
| W4: Bispyribac sodium @ 150 g a.i ha\(^{-1}\) at 20 DAS \(\text{fb.} \) 2,4-D amine salt @ 600 g a.i ha\(^{-1}\) + fenoxprop-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) | 77.6 (166.7) | 84.3 (186.7) | 88.7 (192.8) | 90.1 (196.8) | 90.1 (196.8) | 90.1 (196.8) |
| SEM ± | 0.24 | 0.18 | 0.30 | 0.10 | 0.14 | 0.16 | 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 | 0.82 | 0.63 | 1.03 | 0.34 | 0.47 | 0.54 |
Yashwant Singh, (2018) also reported the effectiveness of sodium weed drymatter which was however, on a par with bispyribac florpyrauxifen-benzyl registered significantly lower total and foliar application of 19-19-19 and KNO₃ was however, found parity with farmers practice at 60 DAS weed drymatter production at all the stages of sampling which Application of 100% RDF registered significantly larger total during critical period of crop-weed competition. Application of bispyribac checked the subsequent flushes growth of weeds during initial stage, while post-emergence pre-emergence application of pyrazosulfuron in controlling harvest. Application of pyrazosulfuron ethyl drymatter production between any two sampling intervals till 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 bispicyribac sodium fb. 2,4-D amine salt + fenoxyprop-ethyl with safener and hand weeding twice at critical periods. Kutikuppala and Yashwant Singh, (2018) also reported the effectiveness of pre-emergence application of pyrazosulfuron in controlling growth of weeds during initial stage, while post-emergence application of bispicyribac 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 KNO₃ 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 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 bispicyribac 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).

### Nutrient Management Practices (N)

| Nutrient Management Practices (N) | 10.22 | 7.44 | 12.50 | 5.62 | 7.57 | 8.94 |
|-----------------------------------|-------|------|-------|------|------|------|
| N₁: Foliar application of 19-19-19 @ 1% at 20 DAS and 2% at 40 DAS fb. 75% RDF from conversion onwards in three splits | (197.6) | (214.4) | (209.5) | (108.5) | (118.3) | (112.6) |
| N₂: Foliar application of 19-19-19 @ 1% at 20 DAS and KNO₃ @ 2% at 40 DAS fb. 75% RDF from conversion onwards in three splits | (197.2) | (215.6) | (206.4) | (108.1) | (120.2) | (114.2) |
| N₃: 100% RDF (Entire P through SSP, 1/3rd N and 1/3rd K as basal and remaining N and K through top dressing as per recommendation) | (225.7) | (240.9) | (231.7) | (119.4) | (124.8) | (122.2) |
| N₄: Farmers practice (Entire P, 1/2 N and K immediately after conversion, remaining N and K at PI stage) | (185.9) | (206.9) | (195.0) | (117.0) | (123.6) | (120.1) |

| SEm | 0.16 | 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)

| Micronutrients (M) | 14.48 | 15.04 | 14.77 | 10.94 | 11.44 | 11.19 |
|---------------------|-------|-------|-------|-------|-------|-------|
| M₁: ZnSO₄ @ 50 kg ha⁻¹ | (214.0) | (232.8) | (222.4) | (127.0) | (137.4) | (132.0) |
| M₂: Foliar application of ZnSO₄ @ 0.2% twice at 20 and 40 DAS | (195.5) | (216.8) | (206.1) | (110.1) | (119.6) | (114.5) |
| M₃: Foliar application of ZnSO₄ @ 0.2% and FeSO₄ @ 0.5% each at 20 and 40 DAS | (192.8) | (214.0) | (203.4) | (102.7) | (108.3) | (105.3) |

| SEm | 0.14 | 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

| Interaction | WXN | WXM | NXM | WXNXM |
|-------------|-----|-----|-----|-------|
| SEm | 0.32 | 0.26 | 0.26 | 0.07 | 0.10 | 0.14 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| SEm | 0.29 | 0.22 | 0.27 | 0.03 | 0.09 | 0.13 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| SEm | 0.29 | 0.22 | 0.27 | 0.03 | 0.09 | 0.13 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
| SEm | 0.57 | 0.43 | 0.55 | 0.07 | 0.18 | 0.25 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS |
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)\textsuperscript{[11]}. Application of ZnSO\textsubscript{4} @ 50 kg ha\textsuperscript{-1} produced significantly taller plants and comparable with foliar feeding of ZnSO\textsubscript{4} twice. Significantly shorter plants were found in plots which received ZnSO\textsubscript{4} and FeSO\textsubscript{4} through foliar feeding. Basal ZnSO\textsubscript{4} might have created a favourable nutria-physiology right from beginning of crop growth resulted in producing taller plants compared to rest of the treatments. Adequate Zn nutrition is essential for meristematic 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)\textsuperscript{[9]}. Larger number of productive tillers m\textsuperscript{-2} was produced with pyrazosulfuron ethyl \textit{fb.} florpyrauxifen-benzyl which was however, found parity with bispyribac sodium \textit{fb.} 2,4-D amine salt + fenoxaprop-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\textsuperscript{-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)\textsuperscript{[10]}. Significantly higher number of productive tillers m\textsuperscript{-2} were noticed with 100% RDF which was however, comparable with foliar application of 19-19-19 twice \textit{fb.} 75% RDF and foliar application of 19-19-19 and KNO\textsubscript{3} \textit{fb.} 75% RDF. Higher number of productive tillers m\textsuperscript{-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\textsuperscript{-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)\textsuperscript{[19]}. Micronutrient management practices were found to influence the productive tiller number m\textsuperscript{-2} of rice to a statistically perceptible level. Basal application of ZnSO\textsubscript{4} @ 50 kg ha\textsuperscript{-1} produced significantly higher numbers of productive tillers m\textsuperscript{-2} which was however, found parity with foliar application of ZnSO\textsubscript{4} twice during both the years and pooled mean. Foliar application of ZnSO\textsubscript{4} and FeSO\textsubscript{4} resulted in significantly lesser number of productive tillers m\textsuperscript{-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\textsuperscript{-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\textsuperscript{-2} |
|------------|------------------|-----------------------------|
|            | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled |
| Weed Control Methods (W) |          |          |          |          |          |          |
| W1: Unweeded check | 83.20 | 80.11 | 81.65 | 305 | 298 | 302 |
| W2: Hand weeding twice at 20 and 40 DAS | 98.14 | 94.50 | 96.32 | 413 | 404 | 408 |
| W3: Pyrazosulfuron ethyl @ 20 g a.i ha\textsuperscript{-1} at 8-12 DAS \textit{fb.} florpyrauxifen-benzyl @ 31.25 g a.i ha\textsuperscript{-1} at 25 DAS | 108.41 | 104.45 | 106.43 | 460 | 450 | 455 |
| W4: Bispyribac sodium @ 150 g a.i ha\textsuperscript{-1} at 20 DAS \textit{fb.} 2,4-D amine salt @ 600 g a.i ha\textsuperscript{-1} + fenoxaprop-ethyl with safener @ 150 g a.i ha\textsuperscript{-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) |          |          |          |          |          |          |
| N1: Foliar application of 19-19-19 @ 1% at 20 DAS and 2% at 40 DAS \textit{fb.} 75% RDF from conversion onwards in three splits | 102.47 | 98.68 | 98.28 | 410 | 401 | 406 |
| N2: Foliar application of 19-19-19 @ 1% at 20 DAS and KNO\textsubscript{3} @ 2% at 40 DAS \textit{fb.} 75% RDF from conversion onwards in three splits | 101.98 | 98.22 | 100.10 | 413 | 404 | 409 |
| N3: 100% RDF (Entire P through SSP, ½rd 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 |
| N4: 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) |          |          |          |          |          |          |
| M1: ZnSO\textsubscript{4} @ 50 kg ha\textsuperscript{-1} | 100.13 | 96.43 | 98.28 | 410 | 401 | 406 |
| M2: Foliar application of ZnSO\textsubscript{4} @ 0.2% twice at 20 and 40 DAS | 98.91 | 95.27 | 97.09 | 406 | 398 | 402 |
| M3: Foliar application of ZnSO\textsubscript{4} @ 0.2% and FeSO\textsubscript{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 |          |          |          |          |          |          |
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)[10]. 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 KNO₃ 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 ZnSO₄ @ 50 kg ha⁻¹ which was however, comparable with foliar feeding of ZnSO₄ twice. While, the grain and straw yields realized with foliar application of ZnSO₄ and FeSO₄ 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 ZnSO₄ 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 ZnSO₄ @ 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) |       |       |       |       |       |       |
| W₁: Unweeded check | 4023 | 3936 | 3979 | 5905 | 5538 | 5721 |
| W₂: Hand weeding twice at 20 and 40 DAS | 5328 | 5107 | 5218 | 6965 | 6458 | 6712 |
| W₃: 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 |
| W₄: 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 |
| 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) |       |       |       |       |       |       |
| N₁: 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 |
| N₂: Foliar application of 19-19-19 @ 1% at 20 DAS and KNO₃ @ 2% at 40 DAS fb. 75% RDF from conversion onwards in three splits | 5527 | 5185 | 5356 | 7206 | 6760 | 6983 |
| N₃: 100% RDF (Entire P through SSP, ⅔rd N and ½ K as basal and remaining N and K through top dressing as per recommendation) | 5626 | 5277 | 5452 | 7341 | 6886 | 7113 |
| N₄: 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 ± | 1.33 | 0.73 | 1.99 | 6.11 | 3.29 | 3.59 |
| 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) |       |       |       |       |       |       |
| M₁: ZnSO₄ @ 50 kg ha⁻¹ | 5550 | 5181 | 5366 | 7175 | 6730 | 6952 |
M1: Foliar application of ZnSO₄ @ 0.2% twice at 20 and 40 DAS
M2: Foliar application of ZnSO₄ @ 0.2% and FeSO₄ @ 0.5% each at 20 and 40 DAS

| CD (P = 0.05) | SEm ± | NS | NS | NS | NS | NS |
|---------------|-------|----|----|----|----|----|
| WXN           |       | 123.12 | 71.78 | 127.84 | 123.53 | 143.95 | 106.92 |
| WXM           |       | 92.57 | 53.21 | 97.70 | 111.57 | 141.80 | 83.75 |
| NXM           |       | 92.57 | 53.21 | 97.70 | 111.57 | 141.80 | 83.75 |
| WXN X NXM     |       | 185.14 | 106.43 | 195.41 | 223.15 | 283.60 | 167.50 |

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