Available online at http://www.journalijdr.com

IJDR

International Journal of
DEVELOPMENT RESEARCH

ISSN: 2230-9926

International Journal of Development Research
Vol. 3, Issue, 10, pp.102-105, October, 2013

Full Length Research Article

NUTRIENT STATUS AND ESTABLISHMENT OF CRITICAL VALUES AND ADEQUATE RANGES FOR DIFFERENT NUTRIENTS FOR RICE (*Oryza sativa* L.) THROUGH DRIS IN KARIMNAGAR DISTRICT OF ANDHRA PRADESH

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ARTICLE INFO

Article History:
Received 15th July, 2013
Received in revised form
31st August, 2013
Accepted 17th September, 2013
Published online 04th October, 2013

Key words:
Adequate values;
DRIS;
CNC;
Critical values;
Sufficiency ranges.

ABSTRACT

The Diagnosis and Recommendation Integrated System (DRIS) foliar diagnostic norms were developed for N, P, K, S, Zn and Fe and identified the yield limiting nutrients in rice, based on crop nutrient survey of 150 rice fields in Karimnagar district of Andhra Pradesh in India. A wide variation in soils and management practices were noticed in selected rice fields under study. Index leaf samples were collected from all the selected fields at tillering stage and analyzed for N, P, K, S, Zn and Fe contents. A wide range of variation in chemical composition in index leaves was observed irrespective of yield level of no uniform trend. Based on critical nutrient concentration (CNC), N, S, Zn and Fe contents in index leaf samples of rice under study were deficient to an extent of 40, 44, 53 and 10% respectively, and no deficiencies were observed with respect to P and K. The extent of nutrient deficiencies diagnosed by CNC method was changed depending up on the critical level adopted. The direct correlation between N, P, K, S, Zn and Fe contents in index leaves and rice yields were poor. Based on the highest variance ratio between low and high yielding populations, forms of expression for different nutrients and their norms were selected. DRIS norms were established for various nutrient ratios obtained from high yielding population of rice crop and were further used to compute the DRIS indices, which assessed the yield limiting nutrients and their requirement in order of priority. The DRIS derived sufficiency ranges for N, P, K and S from nutrient survey of rice crop were 2.2 to 3.6, 0.30 to 0.38, 2.02 to 2.89 and 0.18 to 0.34% respectively. The sufficiency ranges for Zn and Fe were 14.9 to 26.3 and 19.7 to 167.8 mg kg^{-1} respectively. The lower critical values for the nutrients N, P, K, S, Zn and Fe for rice crop were established as 0.2, 0.3, 2.02, 0.18% and 14.93, 91.69 mg kg^{-1} respectively.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the widely cultivated and consumer oriented crop in India, occupying an area of about 43.77 million hectares with production of 69.43 million tonnes. It is an important cereal grown crop in Andhra Pradesh with an area of about 39.84 lakh hectares with the production of 133.24 lakh tonnes and with an average grain yield of 3.34 t/ha. In Karimnagar district, about 2.82 lakh hectares of area is under rice crop with a total production of 19.86 lakh tonnes and with an average grain yield of 3.49 t/ha (DES, 2008). In case of rice, critical level(s) of nutrient content ratio's to identify nutritional imbalances and deficiencies have been reported by Bell and Kovar (2004). These critical levels for rice have been developed outside the state of Andhra Pradesh. There are always some variations among the critical levels suggested by different workers for the same crop. In view of the fast expanding area under rice there is a need to develop specific indices for different nutrients to identify the nutrients deficient or their imbalance(s) in the plant so that the same could be corrected by their application. In view of the success reported in the identification and management of nutrient(s) deficiencies by DRIS indices in case of other crops and tree plants (Walworth and Sumner, 1987), it would be highly desirable to develop DRIS indices for rice, which can help in the diagnosis of nutritional disorder(s) in rice. Very little information is available on these lines in India on rice crop.

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Only handfuls of publications are available on DRIS with other crops or tree species in India.

MATERIALS AND METHODS

Investigation was carried out to assess the nutritional status of rice fields in Karimnagar District of Andhra Pradesh and to develop the Diagnosis and Recommendation Integrated System (DRIS) norms and indices, following the methodology developed by Beaufils (1973), to identify the nutritional requirements. 3^{rd} leaf from top of the plant among the fully developed leaves at tillering stage was collected at random as index leaf from the selected fields for the analysis of nutrients. 15-20 index leaves were collected from each field and composite sample was made. Leaf samples collected were immediately washed first with tap water followed by 0.1 N HCl and followed by repeated washings with running tap water. The samples were then rinsed with distilled water and finally with double distilled water. They were first dried in shade and then in hot air oven at 70^0C. Oven dried plant samples were powdered in a stainless steel grinder to a fineness of 40 mesh and stored in butter paper covers. Processed leaf samples were analyzed for N, P, K, S, Zn and Fe following standard analytical procedures. The extent of deficiencies derived based on critical levels established by different workers were compared.

Derivation of sufficiency ranges

The sufficiency ranges for leaf tissues of rice crop was determined by the DRIS technique. The range of sufficiency's are the values derived from the mean ± 4/3 SD and mean ± 8/3 SD (Standard deviation), respectively (Beaufils 1971; Beaufils and Sumner 1976; Bhargava 2002). The value of nutrients < (mean – 8/3 SD) are considered deficient, whereas their low range included all values between > (maen - 8/3 SD) and < (mean – 4/3 SD). Values between > (mean – 4/3 SD) and < (mean + 4/3 SD) are taken as sufficient, whereas the range between > (mean + 4/3 SD) and < (mean + 8/3 SD) are expressed as high. The nutrient concentrations > (mean + 8/3 SD) are expressed as excessive or toxic.

RESULTS AND DISCUSSION

Nutritional status and deficiencies based on CNC in rice crop

Nitrogen content in leaf index tissue varied from 2.0 to 3.9% with a mean of 2.91% (Table 1). N content of leaves in all the selected rice fields were within the range as reported by Brar *et al.* (1982), but based on the critical level suggested by Bell and Kovar (2004), 40% of the samples were in deficient N. Similarly only 21% of the leaf samples were deficient in N based on the critical level suggested by IRRI (1968) (Table 2 and 3). The mean leaf N recorded was below the critical level based on the Bell and Kover (2004) in 14 mandals out of total 54 mandals (26%), (Table 2 and 4). Most of the selected rice fields under study received nitrogen fertilizers more than the recommended dose of 120 kg ha^{-1} for this zone (ANGRAU 2010). Index leaf samples of low yielding population recorded lesser mean leaf N content (2.83%) than that of high yielding population (3.26%). This may be due to the poor management practices in the fields where low yielders are obtained (Table 5). Phosphorus content of the index leaf samples ranged from 0.18 to 0.56% with a mean of 0.34% (Table 1). The P content in leaf samples in all the 150 selected farmer fields were more than the critical level as suggested by Bell and Kovar (2004) and Hundal *et al.* (2008). The content in rice leaf samples are within the ranges as reported earlier by Singh and Agrawall (2007). Leaf potassium content in the rice index leaves in the district ranged from 1.8 to 3.1% with an overall mean of 2.43% (Table 1), based on the critical levels 1.5, 0.57, 4.35% suggested by Bell and Kovar (2004), Hundal *et al.* (2008) and Brar *et al.* (1982) respectively (Table 2). No potash deficiency was observed in all the rice index leaf samples collected in the district (Table 3). The available potassium in soils was medium to high in the selected rice fields, which may be the reason for having sufficient potassium in leaves in all the selected rice fields. Farmers have applied large quantities of potash fertilizers over and above the recommended dose of 40 kg K_2O ha^{-1}. (ANGRAU 2010), also may be the reason for having sufficient potash contents in the index leaves. Sulphur content of the leaf samples of the rice fields ranged from 0.1 to 0.39% with a mean of 0.26% (Table 1). The sulphur deficiency was noticed to an extent of 44% in the leaf samples of the district based on the critical level of 0.26% suggested by Hundal *et al. (*2008) (Table 2). Singh and Agrawal (2007) also reported similarly ranged of S values in the rice index leaf samples at Varanasi in Uttar Pradesh. Mean available sulphur status in all the selected 54 mandals of the district was above the critical level, which may be reason for having recorded no sulphur deficiency in leaf samples.

Table 1: Nutritional status of index leaves of rice crop of selected farmer fields in Karimnagar district

Nutrient	No of samples/ fields	Range	Mean
N (%)	150	2.0-3.9	2.91
P (%)	150	0.18-0.56	0.34
K (%)	150	1.8-3.1	2.43
S (%)	150	0.1-0.39	0.26
Zn (mg kg^{-1})	150	11.2-36.21	20.62
Fe (mg kg^{-1})	150	61.23-261.15	129.7

Leaf tissue zinc content in the rice fields of the district ranged between 11.2 to 36.21 mg kg^{-1} with a mean of 20.62 mg kg^{-1} (Table 1). The range of zinc content in the leaf samples recorded are similar to the values reported earlier by Bhupal Raj *et al.* (2009). The zinc deficiency was noticed to an extent of 53% in the rice leaf samples in the district, based on the critical level of 20 mg kg^{-1} suggested by Bell and Kovar (2004). But based on the other critical level (15 mg kg^{-1}) suggested by Hundal *et al.* (2008), no samples were deficient in zinc. 50% of the soil samples under study were deficient in available zinc and also in 50% of the selected fields only zinc sulphate was applied. These may be the reasons for getting 53% of the zinc deficiency in rice leaf tissue of the district in the selected samples (Table 2 and 3). The iron content of the leaf samples ranged between 61.23 to 261.15 mg kg^{-1} with a mean 129.72 mg kg^{-1} (Table 1) Similar range of values for iron were reported earliar by Bhupal Raj *et al.* (2009), Fe deficiency in leaf samples was reported only to an extent of 10% in the selected fields based on the critical value 90 mg kg^{-1} as suggested by Bell and Kovar (2004), but there was no deficiency of iron was observed when the critical levels of 70 and 64 mg kg^{-1} suggested by IRRI (1968) and Hundal *et al.* (2008) were followed (Table 2 and 3). The mean N, P, K, S, Zn and Fe contents in the low and high yielding population

Table 2: Critical nutrient concentrations adopted to assess nutritional deficiencies in rice crop

N	P	K	S	Zn	Fe	Reference	Reference Number
%				mg kg^{-1}			
2.8	0.14	1.5	0.17	20	90	Bell and Kovar (2004)	1
2.50 (i)	-	-	0.16 (ii)	-	70 (iii)	i. IRRI (1968) ii. Yoshida and Chaudhry (1979) iii. Takagi 1966	2
1.49	0.14	0.57	0.26	15	64	Hundal *et al* (2008)	3

Table 3: Nutrient deficiencies based on conventional critical nutrient concentration (CNC) in rice crop of selected farmer fields in Karimnagar district

Nutrient	Reference 1		Reference 2		Reference 3	
	No. of fields	Percent deficiency	No. of fields	Percent deficiency	No. of fields	Percent deficiency
N	60	40	32	21	0	0
P	0	0	-	-	0	0
K	0	0	-	-	0	0
S	66	44	10	7	63	42
Zn	80	53	-	-	2	1.34
Fe	15	10	4	3	2	1.34

Table 4: Nutrient deficiencies based on conventional critical nutrient concentration (CNC) in rice crop in different mandals in Karimnagar district

Nutrient	Reference 1		Reference 2		Reference 3	
	No. of mandals	Percent deficiency	No. of mandals	Percent deficiency	No. of mandals	Percent deficiency
N	14	26	6	11	0	0
P	0	0	-	-	0	0
K	0	0	-	-	0	0
S	2	4	1	2	28	52
Zn	27	50	-	-	8	15
Fe	1	2	0	0	0	0

Table 5: Nutritional status of index leaves of rice crop in low and high yielding populations

Nutrient	Low yielding population (37)		High yielding population (113)	
	Range	Mean	Range	Mean
N (%)	2.0-3.90	2.83	2.20-3.90	3.26
P (%)	0.18-0.56	0.62	0.22-0.39	0.32
K (%)	2.5-2.8	2.63	2.10-3.10	2.50
S (%)	0.1-0.39	0.25	0.12-0.39	0.28
Zn (mg kg^{-1})	11.25-34.25	20.24	15.5-36.21	21.78
Fe (mg kg^{-1})	61.23-196.25	129.02	76.75-261.15	131.85

Table 6: Sufficiency ranges of nutrient elements derived by DRIS technique from nutrient indexing survey of rice in Karimnagar district

Nutrient	Mean	S.D	Low	Optimum	High	Excessive
N (%)	2.91	0.533	<2.20	2.20-3.62	3.62-4.33	>4.33
P (%)	0.34	0.303	<0.30	0.30-0.38	0.38-0.42	>0.42
K (%)	2.43	0.348	<2.02	2.02-2.89	2.89-3.36	>3.36
S (%)	0.26	0.062	<0.18	0.18-0.34	0.34-0.42	>0.42
Zn (mg kg^{-1})	20.62	4.275	<14.93	14.93-26.30	26.30-32.03	>32.03
Fe (mg kg^{-1})	129.72	28.59	<91.69	91.69-167.74	167.74-206.0	>206.05

were 2.83, 0.62, 2.63, 0.25, 20.24 and 129.02%; and 3.26, 0.32, 2.50, 0.28, 21.78 and 131.85 percents respectively. In case of high yielding population, the mean leaf contents of N, S, Zn and Fe were more (3.26%, 0.28%, 21.78 and 131.85 mg kg^{-1}) than the low yielding population (2.83%, 0.25%, 20.24 and 129.02 mg kg^{-1}), whereas in the case of low yielding population, the mean leaf content of P and K were more (0.62 and 2.63%) than the high yielding population (0.32 and 2.50%) (Table 5). It may be inferred that only the nutrient ratios reflected much better variations in the grain yield, as reflected by high variance ratio, than by the individual means of nutrients alone. It is well known that the CNC among others was influenced by the different Agro climatic conditions and management of nutrients other than the one being considered for assessment. The applicability of these critical levels in interpreting the nutritional requirements of rice crop is to be conformed by conducting response studies by applying the deficient nutrients in the rice fields. The simple correlations between the nutrient composition of N, P, K, S, Zn and Fe in the index leaves with grain yield were very low (r= 0.376, 0.001, -0.035, 0.301, 0.088 and 0.069 respectively). Therefore the inconsistent trend exists in nutrient composition between the high and low yielding populations. It is shown in the present work that none of the individual parameters N, P, K, S, Zn and Fe contents in leaves reflected the variations of the grain yield in the high and low yielding populations and no DRIS indices were developed for these. It is only the nutrient ratios that reflected much better variations in the grain yield, as reflected by higher variance ratio between high and low yielding populations for various parameters. Ultimately these

ratios only were selected and included in the DRIS indices, thus indicating the advantage of DRIS indices in interpreting the nutritional disorders rather than the contents of individual nutrients.

Nutrient deficiencies in the selected rice fields based on conventional critical nutrient concentration (CNC)

The deficient nutrients were identified based on the critical nutrient concentration as suggested by Bell and Kovar (2004), IRRI (1968), Yoshida and Chaudhry (1979), Takagi (1966) and Hundal *et al*. (2008); Standards suggested by these workers are presented in table 2. Nutrients identified as deficient in index tissues of rice based on the above standards, in all the mandals are given in table 4. Mean nitrogen was deficient in rice leaf samples of 14 mandals out of 54 mandals selected for study, as per the standards given by Bell and Kovar (2004). Phosphorus and Potassium was adequate in all the mandals based on critical level given by both Bell and Kovar (2004) and Hundal *et al.* (2008). Sulphur was noticed to be deficient in 28 mandals out of total 54 mandals based on standard suggested by Hundal *et al.* (2008), but only one mandal (Gollapally mandal) was deficient in S based on the critical level suggested by Yoshida and Chaudhry (1979). Twenty seven mandals were found to be deficient in Zn and only one mandal (Velagatur mandal) was deficient in Fe as per the standards given by Bell and Kovar (2004). The deficiencies of nutrients identified in rice leaf tissue varied based on different critical levels suggested by different workers.

Determination of sufficiency ranges of nutrients by DRIS technique

The sufficiency ranges for leaf tissues of rice crop were determined by the DRIS technique, following the procedure developed by Beaufils (1971); Beaufils and Sumner (1976) and Bhargava (2002). The sufficiency ranges of nutrients derived by DRIS technique are given in table 6. It was found that the optimum ranges for N, P, K and S were 2.20-3.6, 0.30-0.38, 2.00-2.89 and 0.18-0.34% respectively. Similarly the optimum values derived for Zn and Fe were 14.90-26.30 and 91.70-168.0 mg kg^{-1} respectively. The low category values derived from this method for N, P, K, S, Zn and Fe were less than 2.2, 0.30, 2.02, 0.18% and 14.93 mg kg^{-1} and 91.69 mg kg^{-1}. The sufficiency ranges for leaf tissues for rice crop were determined by the DRIS technique, following the procedure developed by Beaufils 1971; Beaufils and Sumner 1976 and Bhargava 2002. The optimum ranges for N, P, K and S derived were 2.20-3.6, 0.30-0.38, 2.00-2.89 and 0.18-0.34% respectively. Similarly the optimum range values derived for Zn and Fe were 14.90-26.30 and 91.70-168.0 mg kg^{-1} respectively. It was also determined that the nutrients N, P, K, S, Zn and Fe can be said deficient, when the concentration of these nutrients are less than 2.2%, 0.3%, 2.02% and 0.18%, 14.93 mg kg^{-1} and 91.69 mg kg^{-1}respectively (Table 6). These values derived in these studies for S and Zn are nearer to the values suggested by Hundal *et al* (2008) at Ludhina in Punjab, but the derived values for N, P, K and Fe are different. Sulphur critical values are similar to the values suggested by IRRI (1968), Yoshida and Chaudhry (1979) and Bell and Kovar (2004). Low category values of Zn and Fe developed in this study are similar to the values developed by Hundal *et al.* (2008) and Bell and Kovar (2004) respectively. The low category values developed for N, P and K in this study are different from those values developed earlier by Bell and Kovar (2004) and Hundal *et al.* (2008) (Table 2). Thus, the DRIS sufficiency ranges from the field survey of rice crop in this district may especially valuable in reassessing the already established one in use and in evaluating the samples when a general dilution or concentration of elements complicates the interpretation.

Conclusion

The extent of nutrient deficiencies varied depends upon the different critical levels adapted developed by different workers. DRIS was better as compared to that of the conventional critical nutrient concentration (CNC) method in case of rice crop. The DRIS derived sufficiency ranges for different nutrient elements can also be computed from foliar diagnostic norms, which can avoid conducting of large number of field experiments on different soil types involving tremendous expenditure. Sufficiency ranges for different nutrient elements can be future employed for nutrient indexing of rice crops grown in different regions.

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