International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 11, Issue 2, 2019, pp.-7751-7754.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

EFFECT OF NITROGEN MANAGEMENT THROUGH DECISION SUPPORT TOOLS ON GROWTH, YIELD AND ECONOMICS IN DIRECT SEEDED RICE (*ORYZA SATIVA* L.) UNDER TUNGABHADRA PROJECT (TBP) COMMAND AREA OF KARNATAKA

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Received: January 03, 2019; Revised: January 20, 2019; Accepted: January 22, 2019; Published: January 30, 2019

Abstract: A field experiment was conducted during *Kharif* 2017 to study the "Nitrogen management through different decision support tools in Direct Seeded Rice (*Oryza sativa* L.) under Tungabhadra Project (TBP) command area of Karnataka" at Agricultural Research Station, Gangavathi. The soil type in the experimental site was medium black soil with soil pH and EC of 7.90 and 0.43 respectively. The initial soil available nitrogen, phosphorus and potassium was 213.2, 31.05 and 374.8 kg ha^{-1}, respectively which is in the range of low in nitrogen, medium in phosphorous and high in potassium content. The experiment consists of 12 treatments laid out in randomized block design with three replications. The results revealed that application of nitrogen through LCC ≤ 6.0 threshold recorded significantly higher grain yield, straw yield, Panicle length, ten panicle weight and number of grains per panicle (6230 kg ha^{-1}, 6323 kg ha^{-1}, 21.0 cm, 43.3 g and 262.0, respectively) compare to RDF (4410kgha^{-1}, 4853 kg ha^{-1}, 17.8 cm, 30.0 g and 219.7, respectively) and farmer practice (5086 kgha^{-1}, 5330 kg ha^{-1}, 18.2 cm, 35.8 g and 247.3, respectively)which was on par with application of N through LCC ≤ 5.0, SPAD ≤ 40, SPAD ≤ 50 and Green Seeker ≤ 0.8. Similar trend was also observed in growth parameters *viz*., plant height, leaf area, total dry matter production plant^{-1} and Number of tillers m^{-2}. However, gross returns, net returns and B:C ratio was significantly higher with application of nitrogen through LCC ≤ 6.0 threshold (102847,59332Rs. ha^{-1} and 2.36, respectively), which was on par with LCC ≤ 5.0 threshold, SPAD ≤ 40, SPAD ≤ 50 and Green Seeker ≤ 0.8as compared to RDF (82422, 39682Rs. ha^{-1}and 1.92, respectively) and farmers practice (87341,43020Rs. ha^{-1}and 1.97, respectively). Hence, precision nitrogen management in DSR can be done through LCC ≤ 5.0 or SPAD ≤ 50 and green seeker ≤ 0.8 threshold for obtaining higher growth, yield and economics.

Keywords: DSR, Decision support tools, Economics, Grain yield, Nitrogen management

Citation: Gurupadappa, *et al*., (2019) Effect of nitrogen management through decision support tools on growth, yield and economics in Direct Seeded Rice (*Oryza sativa* L.) under Tungabhadra Project (TBP) command area of Karnataka. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 11, Issue 2, pp.- 7751-7754.

Academic Editor / Reviewer: Murat Aydın

Introduction

Rice (*Oryza sativa* L.) is the most important food crop of India covering about one-fourth of the total cropped area and providing food to about half of the Indian population. Worldwide, rice is grown in 161 m ha, with an annual production of about 678.7 mt of paddy. About 90 percent of the world's rice is grown and produced (143 m ha of area with a production of 612 mt of paddy) in Asia. In India produces 104.3 mt in an area of more than 43.9 m ha with a productivity of 2223 kg ha^{-1}. In recent years, Direct Seeded Rice (DSR) is becoming a popular rice cultivation practice in Karnataka. It's mainly due to water and labour scarcity. The tail end farmers do not get sufficient water at right time due to shortfall of rainfall every year resulting in declining resources. In TBP command area, cultivation of paddy is characterized by use of more N fertilizer without scientific base is the common practice besides unscientific water management followed by the formers of this command. In this context, management of N fertilizer to increase NUE and to avoid ground water contamination is need of the hour. IRRI Philippines introduced LCC is a hand-held plastic strip, that can be used as a complementary decision-making tool to determine the need for N application in field periodically. LCC has now been used successfully to guide fertilizer N application in rice, wheat and maize [1-3]. The SPAD meter is a hand held, simple, quick and non-destructive in-situ tool for measuring relative content of chlorophyll in leaf that is directly proportional to leaf N content. Hence, the SPAD chlorophyll meter is used to diagnose the N status in crops and determine the right time of N application [4].

The application of optical sensors in agriculture has advanced rapidly in the recent years. The Green seeker optical sensor works on reflection of light from the chlorophyll, similarly, these sensors use visible and near-infrared (NIR) spectral radiation from plant canopies to detect N stress and crop vigour (NDVI) values are used as the basis for nitrogen application. NDVImeasurementscanrangefrom-1 to, with higher values indicating better plant health. It has the ability to predict yield potential of crops. When we go for broad-based blanket recommendations of fertilizer N in field may end up with lower nutrient use efficiency because of large field-to field variability of soil N, so keeping in view the significance of N on productivity of rice, crop need based N fertilizer application through some of the decision support tools like LCC, SPAD and Green seeker will reduced the N losses, cost of fertilizer and application cost. Hence, there is urgent need to find out nitrogen threshold limit for direct seeded rice under TBP command area.

Material and Methods:

The field experiment was carried out at Agricultural Research Station, Gangavathi during *kharif*-2017 to study the "Nitrogen management through decision support tools in direct seeded rice (*Oryza sativa* L.) under Tungabhadra Project (TBP) command area." The experiment was laid out in Randomized Complete Block Design with three replications. There were twelve treatment consisted of T_1 - LCC ≤ 3.5 threshold, T_2 - LCC ≤ 4.0 threshold, T_3 - LCC ≤ 4.5 threshold,T4 - LCC ≤ 5.0 threshold, T_5 - LCC ≤ 6.0 threshold, T_6 - SPAD ≤ 40, T_7 - SPAD ≤ 50, T_8 -

Table-1 *LCC, SPAD and Green Seeker values before N fertilizer application.*

Tr. No.	Treatments	Basal dose	Decision support tools values							
		(kg N ha^{-1})	10 days interval (30 DAS)							
			10-Sep	20-Sep	30-Sep	10-Oct	20-Oct	30-Oct	10-Nov	Total
T_1	LCC ≤ 3.5 threshold	-	2	2.9	3.75	4	4.2	4.3	4.2	60
T_2	LCC ≤ 4.0 threshold	-	2.4	3.1	4.15	4.2	4.25	4.3	4.2	60
T_3	LCC ≤ 4.5 threshold	-	2.2	3.2	4	4.4	4.59	4.65	4.55	120
T_4	LCC ≤ 5.0 threshold	-	2.5	3	4.2	4.5	4.85	5.2	5	150
T_5	LCC ≤ 6.0 threshold	-	2.6	3.5	4.45	5.25	5.75	6.05	5.8	180
T_6	SPAD ≤ 40	-	26.8	32.1	35.5	38.7	42.5	43.5	38.9	150
T_7	SPAD ≤ 50	-	27.2	33.2	37.6	42.9	46.8	48.4	51.1	180
T_8	Green Seeker ≤ 0.6	-	0.31	0.41	0.5	0.58	0.65	0.64	0.59	150
T_9	Green Seeker ≤ 0.8	-	0.32	0.46	0.57	0.68	0.76	0.83	0.78	180
T_{10}	RDF (150:75:75)	75	-	20	-	-	30	-	30	150
T_{11}	Farmers practice(200:100:66)	100	-	-	-	-	55	-	-	200
T_{12}	Absolute control	-	-	-	-	-	-	-	-	-

Note - RDF: (150:75:75 N: P_2O_5: K_2O kg ha^{-1}) and Farmers practice: (200:100:66 N: P_2O_5: K_2O kg ha^{-1}).

Table-2 *Quantity of N fertilizer applied in different treatments*

Tr. No.	Treatments	Basal dose	Top dress							
		(kg N ha^{-1})	10 days interval (kg N ha^{-1})							
			10-Sep	20-Sep	30-Sep	10-Oct	20-Oct	30-Oct	10-Nov	Total
T_1	LCC ≤ 3.5 threshold	-	30	30	-	-	-	-	-	60
T_2	LCC ≤ 4.0 threshold	-	30	30	-	-	-	-	-	60
T_3	LCC ≤ 4.5 threshold	-	30	30	30	30	-	-	-	120
T_4	LCC ≤ 5.0 threshold	-	30	30	30	30	30	-	-	150
T_5	LCC ≤ 6.0 threshold	-	30	30	30	30	30	-	30	180
T_6	SPAD ≤ 40	-	30	30	30	30	-	-	30	150
T_7	SPAD ≤ 50	-	30	30	30	30	30	30	-	180
T_8	Green Seeker ≤ 0.6	-	30	30	30	30	-	-	30	150
T_9	Green Seeker ≤ 0.8	-	30	30	30	30	30	-	30	180
T_{10}	RDF (150:75:75)	75	-	20	-	-	30	-	30	150
T_{11}	Farmers practice(200:100:66)	100	-	-	-	-	55	-	-	200
T_{12}	Absolute control	-	-	-	-	-	-	-	-	-

Note - RDF: (150:75:75 N: P_2O_5: K_2O kg ha^{-1}) - Basal (75 Kg N ha^{-1}) and 2 Split (37.5 Kg N ha^{-1}) at 60, 90 DAS each.
Farmers practice: (200:100:66 N: P_2O_5: K_2O kg ha^{-1}) - Basal (100 Kg N ha^{-1}) and 2 Split (50 Kg N ha^{-1}) at 60, 90 DAS each.

Table-3 *Plant height (cm), leaf area (cm^2), total dry matter production (g)and number of tillers m^{-2} of direct seeded rice as influenced by N management through different decision support tools*

Treatments		Plant height (cm)	Leaf area (cm^2)	Total dry matter production (g)	Number of tillers m^{-2}
T_1	LCC ≤ 3.5 threshold	73.47	563.55	22.51	166.1
T_2	LCC ≤ 4.0 threshold	77.6	735.95	28.95	181.2
T_3	LCC ≤ 4.5 threshold	81.73	822.1	30.93	206.6
T_4	LCC ≤ 5.0 threshold	85.13	904.4	35.01	230.4
T_5	LCC ≤ 6.0 threshold	86.68	911.7	35.77	235.3
T_6	SPAD ≤ 40	83.4	872.93	33.47	216.1
T_7	SPAD ≤ 50	84.43	894.55	34.24	222.4
T_8	Green Seeker ≤ 0.6	80.14	805.58	30.56	197.2
T_9	Green Seeker ≤ 0.8	82.3	846.2	32.98	211.8
T_{10}	RDF (150:75:75 N: P_2O_5: K_2O kg ha^{-1})	75.85	654.35	27.81	173.5
T_{11}	Farmers practice(200:100:66 N: P_2O_5: K_2O kg ha^{-1})	78.93	793.54	30.04	193.4
T_{12}	Absolute control	60.97	464.1	20.09	130.2
S. Em.±		1.47	22.8	0.95	8.4
C.D. at 5%		4.39	68.2	2.83	25.3

Table-4 *Grain yield(kg ha^{-1}), straw yield(kg ha^{-1}), panicle length (cm), ten panicle weight (g)and number of grains panicle-1 of direct seeded rice as influenced by N management through different decision support tools*

Treatments		Panicle Length (cm)	Ten panicle Weight (g)	Number of grains panicle^{-1}	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	LCC ≤ 3.5 threshold	17.5	28.5	209.7	3852	4104
T_2	LCC ≤ 4.0 threshold	17.9	34.5	224.7	4604	4879
T_3	LCC ≤ 4.5 threshold	18.8	38.3	252.7	5318	5700
T_4	LCC ≤ 5.0 threshold	20.8	42.2	259.7	6156	6243
T_5	LCC ≤ 6.0 threshold	21	43.3	262	6230	6323
T_6	SPAD ≤ 40	19.8	40.2	256	5723	5893
T_7	SPAD ≤ 50	20	41.1	257.7	5859	6129
T_8	Green Seeker ≤ 0.6	18.2	36.6	251	5270	5656
T_9	Green Seeker ≤ 0.8	19.8	39.1	255.3	5513	5800
T_{10}	RDF (150:75:75 N: P_2O_5: K_2O kg ha^{-1})	17.8	30	219.7	4810	5153
T_{11}	Farmers practice (200:100:66 N: P_2O_5: K_2O kg ha^{-1})	18.2	35.8	247.3	5286	5530
T_{12}	Absolute control	17.1	23	191.7	2290	2661
S. Em.±		0.4	1.5	2.7	249	210
C.D. at 5%		1.2	4.5	7.9	748	617

Table-5 *Cost of cultivation, Gross returns, Net returns and Benefit cost ratio of direct seeded rice as influenced by N management through different decision support tools*

Treatments		Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit cost ratio
T_1	LCC ≤ 3.5 threshold	41950	63685	21735	1.52
T_2	LCC ≤ 4.0 threshold	41950	76099	34149	1.81
T_3	LCC ≤ 4.5 threshold	42733	89533	46800	2.1
T_4	LCC ≤ 5.0 threshold	43125	101618	58233	2.34
T_5	LCC ≤ 6.0 threshold	43515	102847	59332	2.36
T_6	SPAD ≤ 40	43124	94515	51391	2.19
T_7	SPAD ≤ 50	43516	96801	53285	2.22
T_8	Green Seeker ≤ 0.6	43125	87148	44023	2.02
T_9	Green Seeker ≤ 0.8	43516	90900	47384	2.09
T_{10}	RDF (150:75:75 N: P_2O_5: K_2O kg ha^{-1})	42740	82422	39682	1.92
T_{11}	Farmers practice(200:100:66 N: P_2O_5: K_2O kg ha^{-1})	44321	87341	43020	1.97
T_{12}	Absolute control	36000	37965	1965	1.05
S. Em.±			4300	4300	0.1
C.D. at 5%			12614	12614	0.29

Green Seeker ≤ 0.6, T_9 - Green Seeker ≤ 0.8, T_{10} - RDF (150:75:75 N: P_2O_5 : K_2O kg ha^{-1}), T_{11} - Farmers practice (200:100:66 N: P_2O_5 : K_2O kg ha^{-1}), T_{12} - Absolute control. The soil was medium black with pH of 7.9, EC (0.43 dS m^{-1}), Organic carbon 0.46 and available Nitrogen, Phosphorous and Potassium (213.2. 31.05 and 374.8 kg ha^{-1}, respectively). Nitrogen fertilizer applied based on LCC, SPAD and Green Seeker value recorded at 10 days interval [Table-1] and [Table-2]. The gross plot size was 6.0 m × 6.0 m and net plot size was 5.2 m × 5.6 m. Two seeds per hill were dibbled 5 cm deep in furrows at a spacing of 20 cm x 10 cm. Phosphorous and Potassium fertilizer was applied at 30 DAS while, nitrogen fertilizer was applied as per the treatments. The weed management was done through spraying of pre-emergent application of pendimethaline 38.7 CS @ 2.5 ml/ltr of water followed by two hand weeding at 30 and 45 DAS. Three plants were selected randomly for LCC, SPAD and green seeker reading was taken in the morning 10 am to 11 am in three leaves of each plant (lower, middle and upper) and average value was taken for N application. The crop was irrigated once in ten days before application of nitrogen fertilizer. Crop protection was done as per package of practice. Growth observations were recorded 30, 60, 90 DAS and at harvest. The yield observations were recorded at time of harvest. The crop was harvested at its physiological maturity. The data was statistically analyzed as per the procedure given by Gomez (1972) [5].

Results and Discussion

Growth parameters

Results revealed that, at harvest application of N through LCC ≤ 6.0 threshold recorded significantly higher plant height, leaf area, total dry matter production $plant^{-1}$ and Number of tillers m^{-2} (86.68 cm, 911.70, 35.77 g and 235.3, respectively) and was on par with application of N through LCC ≤ 5.0 (85.13 cm, 904.40, 35.01 g and 230.4, respectively), SPAD ≤ 40 (83.40 cm, 872.93, 33.47 g and 216.1, respectively), SPAD ≤ 50 (84.43 cm, 894.55, 34.24 g and 222.4, respectively) and Green Seeker ≤ 0.8 (82.30 cm, 846.20, 32.98 g and 211.8, respectively) compare to other treatments. Whereas, absolute control recorded significantly smaller plants compare to other treatments [Table-3]. Increase in growth attributes namely plant height, total dry matter accumulation, leaf area and number of tillers. The plant height had the predominant role in the accumulation of dry matter. Higher height in these treatments helped in accumulating higher dry matter in stem and leaves. Higher plant height resulted in a greater number of leaves on each stem. At optimum and at higher N levels the number of leaves was high thus improving in the leaf area. Nevertheless, irrespective of crop growth stage, the number of tillers varied in accordance with the quantity of N applied, higher value was recorded in treatment received a higher uptake of nitrogen. The similar results were also obtained by Sathiya and Ramesh, (2009) [6] and Gupta *et al.* (2011) [7].

Yield and yield parameters

Results revealed that, at harvest application of N through LCC ≤ 6.0 threshold recorded significantly higher grain yield, straw yield, panicle length, ten panicle weight and Number of grains $panicle^{-1}$ (6230 kg ha^{-1}, 6323 kg ha^{-1}, 21.0 cm, 43.3 g and 262.0, respectively) and was on par with application of N through LCC ≤ 5.0 (6156 kg ha^{-1}, 6243 kg ha^{-1}, 20.8 cm, 42.2 g and 259.7, respectively), SPAD ≤ 40 (5723 kg ha^{-1}, 5893 kg ha^{-1}, 19.8 cm, 40.2 g and 256.0, respectively), SPAD ≤ 50 (5859 kg ha^{-1}, 6129 kg ha^{-1}, 20.0 cm, 41.1 g and 257.7, respectively) and Green Seeker ≤ 0.8 (5513 kg ha^{-1}, 5800 kg ha^{-1}, 19.8 cm, 39.1 g and 255.3, respectively) compare to other treatments. Whereas, absolute control recorded significantly smaller plants compare to other treatments [Table-4]. Application of N through LCC ≤ 6.0 threshold (180 kg N ha^{-1}) recorded higher grain yield, straw yield, panicle length, ten panicle weight and Number of grains $panicle^{-1}$ over the farmer's practice (200 kg N ha^{-1}), indicating a saving of 10.0 percent N fertilizer over farmers' method. This was in turn on par with LCC ≤ 5.0 (150 kg N ha^{-1}), SPAD ≤ 40 (150 kg N ha^{-1}), SPAD ≤ 50 (180 kg N ha^{-1}) and Green Seeker ≤ 0.8 (180 kg N ha^{-1}) indicating a saving of N to a tune of 25 and 10 percent each, respectively over farmer's practice. This could be due to greater nitrogen use efficiency and better crop root growth system resulted in timely and adequate supply of nitrogen at critical growth stage. These results were conformity with the findings of Angadi *et al.* (1999) [8] who reported higher grain yield in rice variety Abhilash at the LCC threshold of 5.0 than the recommended practice in rice. The above results are in line with findings of Kumar *et al.* (1999) [9], Subbaiah *et al.* (1999) [10], Porpavai *et al.* (2000) [11] and Ravi *et al.* (2007) [12].

Economics

Gross returns, net returns and B:C ratio was significantly higher with application of nitrogen through LCC ≤ 6.0 threshold (102847, 59332 Rs. ha^{-1} and 2.36, respectively), which was on par with LCC ≤ 5.0 threshold (101618, 58233 and 2.34, respectively), SPAD ≤ 40 (94515, 51391 and 2.19, respectively), SPAD ≤ 50 (96801, 53285 and 2.22, respectively), Green Seeker ≤ 0.8 (90900, 47384 and 2.09, respectively) as compared to RDF (82422, 39682 and 1.92, respectively) and farmers practice (87341, 43020 and 1.97, respectively).Whereas, absolute control recorded significantly lower net returns compare to other treatments [Table-5]. Increase in LCC ≤ 3.5 to LCC ≤ 6.0 increased the net returns to a tune of 172.9 percent. Similarly, the percent increase in net returns in LCC ≤ 5.0, SPAD ≤ 40, and Green Seeker ≤ 0.8 (167.9%, 136.4% and118.0%, respectively). The benefit cost ratio was higher at LCC ≤ 6.0 (2.36), LCC ≤ 5.0 (2.34), SPAD ≤ 40 (2.19), SPAD ≤ 50 (2.22) and Green Seeker ≤ 0.8 (2.09) over RDF and farmers practice, indicating LCC ≤ 5.0 and SPAD ≤ 40 could be the optimum level. The above results are in line with the findings of Balasubramanian *et al.* (2000) [13] and Mallikarjuna *et al.* (2016) [14] who opined that need-based application of N fertilizer following LCC, SPAD and Green Seeker revealed substantial gains to farmers through reduction of N and insecticides use, and a small increase in grain yields and income over farmers' practice.

Conclusion

Among the different decision support tools, threshold value of LCC≤ 6.0, recorded higher growth, yield and economics as compare to other treatments. However, there was much difference in the yield between LCC≤ 6.0 and 5.0, SPAD ≤ 40 and 50. Hence, LCC ≤ 5.0and SPAD ≤ 40 was found optimum for DSR in TBP command area as evidenced in higher net returns and B: C ratio.

Application of research:

- Farmers can be use LCC easily to save N fertilizers which is the major culprit in GHGs emission in agriculture.
- Skill is needed to use SPAD and Green Seeker. Hence, plant scientist and extension workers should guide the farmers while using it.
- Precise N application is possible by using these tools so that N fertilizer can be save.

Research Category: Nitrogen management

Acknowledgement / Funding: Authors are thankful to University of Agricultural Sciences, Raichur, Karnataka, 584104 India

***Research Guide or Chairperson of research: Dr S.R. Anand**
University: University of Agricultural Sciences, Raichur, Karnataka, 584104 India
Research project name or number: PhD Thesis

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Conflict of Interest: None declared

Study area / Sample Collection: Agricultural Research Station, Gangavathi during kharif-2017

Cultivar / Variety name: *Oryza sativa* L

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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