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Evaluation of Paddy (*Oryza sativa* L.) Varieties for Salt Tolerance in Saline Vertisols of Tungabhadra Project Command Area

Santosh*, Vishwanath, J., Anand, S. R., Veeresh, H. and Balanagoudar, S. R.

Department of Soil Science and Agricultural Chemistry

College of Agriculture, University of Agricultural Sciences, Raichur - 584104

*Corresponding Author E-mail: sdpolicepatil44@gmail.com

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ABSTRACT

A field experiment was conducted at Agricultural Research Station, Gangavathi during Kharif, 2016 on "Evaluation of paddy varieties for salt tolerance and their response to nitrogen application in saline vertisols of TBP command area". The main-plot consisted of nitrogen levels (100% RDN, 125% RDN and 150% RDN) and sub-plot with paddy varieties (BPT-5204, GGV-05-01, CSR-22, CSR-23, CSR-27 and CSR-36). Plant height as expected showed increasing trend across the physiological stages and at harvest. Among N levels, N_3 (150% RDN) had significantly higher plant height and number of tillers per hill compared to N_1 and N_2. The variety CSR-23 recorded significantly higher plant height whereas GGV-05-01 recorded significantly higher number of tillers per hill compared to other varieties.

Yield attributes of paddy viz., number of panicles per m^2, panicle length, panicle weight, filled grains per panicles and test weight, were significantly higher in N_3, compared to N_1 and N_2. Accordingly, the grain yield increase in N_3 (5490 kg ha^{-1}) was 11.90% and 6.27% higher than N_1 (100% RDN) and N_2 (125% RDN) respectively. Similarly, the straw yield was higher in N_3 (150% RDN) compared to N_1 and N_2. The variety V_5 (GGV-05-01) was significantly superior in terms of number of panicles m^{-2}, panicle weight, number of filled grains per panicle and grain filling percentage over other varieties. Accordingly GGV-05-01 recorded significantly higher grain yield (5684 kg ha^{-1}) compared to CSR-23 (5036 kg ha^{-1}), BPT-5204 (4285 kg ha^{-1}) and CSR-27 (5228 kg ha^{-1}) but was on par with CSR-36 (5504 kg ha^{-1}) and CSR-22 (5393 kg ha^{-1}), respectively. Similarly, GGV-05-01 also recorded significantly higher straw yield (7052 kg ha^{-1}) compared to rest of the varieties except CSR-36 and CSR-22.

Key words: *Grain yield, Nitrogen levels, Salinity, Straw yield, Varieties.*

INTRODUCTION

Paddy (*Oryza sativa* L.) is a staple food for 65% of the total population in India and is consumed by more than one half of the world's population. In India, paddy is cultivated in an area of 43.95 m ha with a production of 106.54 M t. In India, paddy is grown in almost all the states.

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In Karnataka, total area is 1.35 m ha with a production of 3.76 M t and productivity of 2828 kg ha^{-1} [2]. Usually, paddy is cultivated under transplanted submerged condition over a large area. Though only eight per cent of the Tungabhadra Project (TBP) command was earmarked for paddy cultivation, over 40% of the command area is under paddy-paddy cropping system and Gangavati is considered to be the "Rice Bowl of Karnataka".

Among abiotic stresses, soil salinity is a major constraint limiting crop production. Approximately 100 m ha in South and South-east Asia is covered by problematic soils where rice is the staple crop[6]. Due to unscientific irrigation management and paddy-paddy mono-cropping system in shallow to medium black soils in Tungabhadra irrigation project (TBP) has resulted in development of water logging and soil salinity problems in the command. As reported by CADA-TBP nearly 96215 ha of irrigated land is afflicted by soil salinity and water logging. Though reclamation of waterlogged saline soils is underway, build up soil salinity is taking place on the other hand. When it is grown under puddled transplanted conditions, paddy is considered to be one of the most suitable crops for saline soils as it is moderately sensitive to salinity[1,9,13]. However, performances of varieties are known to vary under varying soil salinity conditions.

The popular variety BPT-5204 locally called Sambhamasuri or Sonamasuri is a long duration variety, matures at around 140-150 days. This variety is excellent in grain quality and is a locally preferred variety over the decades. However, the performance of BPT-5204 is reported to be poor when grown under saline conditions since the yield levels decline with increase in soil salinity. Further, in recent years due to its greater susceptibility to pest and diseases, farmers are showing lack of interest for its cultivation. Hence, there is a need to evaluate the performance of some of the salt tolerant varieties released locally and elsewhere under saline vertisols of TBP command.

Nitrogen is the key element that governs the crop yield to a larger extent. Nitrogen fertilization plays a key role in plant physiological process and influence sink size there by increasing the grain yield of rice[18]. It is a constituent of many plant cell components including amino acids, protein and nucleic acids. Among all the mineral elements, its requirement is largest (about 80%) of the total nutrients absorbed by the plant[12].

The nitrogen in soil is more dynamic and its losses through various mechanisms particularly under submerged rice ecosystem may lead to its low use efficiency which is the most important yield limiting factor as for as paddy cultivation is concerned. In addition, N is the most limiting nutrient for crop production particularly in saline soils as they are poor in available N status and/or organic matter content. Furthermore, volatilization is a major N loss mechanism that reduces the efficiency of applied N and the losses known to increase with increase in salinity. Thus, there is a need to evaluate the performances of varieties to graded levels of nitrogen so as to optimize its requirement as well.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* 2016 at Agricultural Research Station, Gangavathi, Karnataka, India which is situated in the north-eastern dry zone of the state. The pH and ECe in surface (0-15) and sub-surface (15.30) soils were 8.45 and 8.55 and 6.30 and 6.85 dS m^{-1} respectively. Soil organic carbon contents were 0.62 and 0.46 percent and available N, P_2O_5 and K_2O contents were 205.5 and 184.6 kg ha^{-1}, 21.6 and 19.4 kg ha^{-1} and 260.6 and 225.4 kg ha^{-1}, in surface and subsurface soils respectively. The soil exchangeable Ca and Mg in surface and subsurface soil was 535.5 and 515.6 ppm and 265.6 and 254.6 ppm respectively. The available S in surface and subsurface soil was 34.7 and 45.1 ppm, respectively. The DTPA-Zn, Fe, Mn and Cu in surface and subsurface soil was 0.29 and 0.24 ppm, 1.88 and 1.60 ppm, 7.33 and 5.10 ppm and 1.48 ppm and 1.28 ppm, respectively.

The experiment was laid out in a split plot design with eighteen treatments and three replications each of plot size of 5 m x 4 m (20 m^2). The main-plot consisted of nitrogen levels (100% RDN, 125% RDN and 150% RDN) and sub-plot with six paddy varieties (BPT-5204, GGV-05-01, CSR-22, CSR-23, CSR-27 and CSR-36). The paddy seedlings were transplanted on 28th July 2016 at a spacing of 20 × 10 cm and followed standard cultural practices as per package of practices except the treatments under study. Full dose of phosphorus and potassium and 50 % of nitrogen was supplied at the time of transplanting. Remaining dose of nitrogen was applied in two splits of 25 percent at 30 and 60 days after transplanting.

RESULTS AND DISCUSSION

Growth parameters

Except at active tillering (AT) stage the plant height showed significant differences at all other crop growth stages. The treatment N_3 (78.5, 100.1 and 102.9 cm) had significantly higher plant height compared to N_1 and N_2 at PI, FL and harvest (Table 1). This could be due to enhanced uptake nitrogen and other nutrients like P and K which are depleted to a greater extent in soil (data not shown) in these treatments would have resulted in increased vegetative growth with higher levels of N. The results are in agreement with the findings of Sankalpa[16]. and Chathurvedi[4]. who reported more dry matter accumulation with increased availability of soil N which has a significant influence on the vegetative growth of plant[15,17]. Genotypes had significant effect on plant height and the variety CSR-23 (V_3) (80.6, 91.9, 113.4 and 116.3 cm) had significantly higher plant height compared to CSR-36 (V_1), CSR-22 (V_2), BPT-5204 (V_4), GGV-05-01 (V_5) and CSR-27 (V_6) at AT, PI ,FL stage and at harvest, respectively.

Number of tillers per hill increased with increased levels of N and crop growth stages. However, the increase was more pronounced from AT to PI than PI to FL or harvest. At AT, PI stage and at harvest treatment N_3 had significantly higher number of tillers per hill (11.1, 15.3 and 16.6) compared to N_1 (8.9, 13.1 and 14.4) and N_2 (10.1, 14.3 and 15.5), respectively. The findings are in line with the observations of Sankalpa[16] who reported that increased number of tillers per hill could be expected up to 40% N in excess of RDF N. Choudhary and Pandey[5] and Manzoor *et al*.[11], also reported similar observations. Among the varieties, GGV-05-01 (V_5) recorded significantly higher number of tillers per hill at AT, PI stage and at harvest (10.8, 15.0 and 16.1) as compared to CSR-36 (V_1), CSR-22 (V_2), CSR-27 (V_6) and CSR-23 (V_3) but at par with BPT-5204 (V_4).

Yield and yield parameters

The yield attributes except panicle length, *viz.*, unfilled grains per panicle and test weight, the number of panicles per m^2, panicle weight, number of filled grains per panicle and grain filling percentage except panicle length were increased significantly with increased levels of N applied (Table 2). In general, the treatment N_3 recorded significantly higher number of panicles per m^2 (586.3), panicle weight (3.64 g), number of filled grains per panicle (146.9) and grain filling percentage (92.6) compared to N_1 but at par with N_2. This could be attributed to the reason that increased plant growth parameter *viz.*, plant height and number of tillers per hill due to better availability of nutrients with the increased levels of N might have improved the yield attributes as well. These results are in agreement with findings of Mahendra Singh Pal *et al.*[10], who also reported that higher application of N resulted in significant increase panicles per m^2, filled grains per panicle, panicle weight of rice etc.

Among the varieties, except panicle length, unfilled grains per panicle and test weight, GGV-05-01 was significantly superior in terms of number of panicles m^2 (640.8), panicle weight (3.82 g), number of filled grains per panicle (162.8) and grain filling percentage (93.5) over rest of the varieties. Higher depletion of soil nutrients and improved growth parameter particularly number of tillers per hill under GGV-05-01 compared to other genotypes would have contributed to significantly higher yield attributes.

In accordance with growth and yield attributes, the grain yield differed significantly among N levels and genotypes studied (Table 3). The treatment N_3 recorded significantly higher grain yield (5490 kg ha^{-1}) compared to N_1 (4906 kg ha^{-1}) and N_2 (5166 kg ha^{-1}) which accounts to about 11.90% and 6.27% increase over N_1 (100% RDN) and N_2 (125% RDN) respectively. The yield increases with the increasing level of N from 100 to 150% RDN was also reported by Bhowmick and Nayak[3]. Higher yield at N_3 may be ascribed to the overall improvement in plant vigor and production of sufficient photosynthates owing to greater availability of nutrients particularly under salinity stress subsequently resulting in better manifestation of yield attributes[5]. The results are in line with the findings of Mahendra Singh Pal *et al.*[10], wherein nitrogen application had significant positive effect on grain yield.

Among the varieties, GGV-05-01 recorded significantly higher (5684 kg ha^{-1}) grain yield as compared to CSR-27 (5228 kg ha^{-1}), CSR-23 (5036 kg ha^{-1}) and BPT-5204 (4285 kg ha^{-1}) but was at par with CSR-36 (5504 kg ha^{-1}) and CSR-22 (5393 kg ha^{-1}). The traditional popular local rice variety of TBP command *i.e.,* BPT-5204 recorded the lowest grain yield as compared to rest of the varieties. Similar results were also observed by Panda *et al.*[14], in coastal saline soils of Orissa.

As for as straw yield, the N_3 (7147 kg ha^{-1}) recorded significantly higher yield than N_2 (6402 kg ha^{-1}) and N_1 (5969 kg ha^{-1}) (Table 3). It could be attributed to the reason that any additional dose of N applied (beyond RDN) might have been utilized for enhancing straw production rather than grain. Sankalpa[16]. and Yadav *et al.*[21], also reported that more straw yield could be explained as rice utilize more N through the expression of better growth by accumulating more dry matter at higher levels of N applied. Among varieties, GGV-05-01 recorded significantly higher straw yield (7052 kg ha^{-1}) as compared to CSR-23 (6316 kg ha^{-1}), BPT-5204 (5548 kg ha^{-1}) but on par with CSR-36 (6797 kg ha^{-1}), CSR-22 (6759 kg ha^{-1}) and CSR-27 (6925 kg ha^{-1}).

Based on results of the present study, it could be inferred that, there was a significant response to applied nitrogen up to 150% RDN in terms of growth and yield attributes of rice varieties. Due to improved growth and yield attributes, GGV-05-01 recorded significantly higher grain yield as compared to rest of the varieties except CSR-36 and CSR-22.

Table 1: Plant height and number of tillers per hill at different growth stages of paddy as influenced by different treatments

Treatments	Plant height (cm)				Number of tillers per hill		
	Active tillering	Panicle initiation	Flowering	At harvest	Active tillering	Panicle initiation	At harvest
Main plot: Nitrogen level							
N_1 : 100% RDN	61.9	73.1	94.8	97.4	8.9	13.1	14.4
N_2 : 125% RDN	64.0	75.2	96.7	99.5	10.1	14.3	15.5
N_3 : 150% RDN	67.2	78.5	100.1	102.9	11.1	15.3	16.6
S.Em.±	**1.30**	**0.58**	**0.65**	**0.81**	**0.07**	**0.16**	**0.17**
CD @ 5%	**NS**	**2.28**	**2.57**	**3.18**	**0.29**	**0.63**	**0.67**
Sub plot: Varieties							
V_1 : CSR-36	64.9	75.7	97.7	100.02	10.0	14.2	15.9
V_2 : CSR-22	69.2	80.4	102.0	104.8	10.0	14.2	15.3
V_3 : CSR-23	80.6	91.9	113.4	116.3	9.7	13.9	15.1
V_4 : BPT-5204	46.3	57.5	79.1	81.8	10.4	14.6	15.7
V_5 : GGV-05-01	61.4	72.8	94.3	97.1	10.8	15.0	16.1
V_6 : CSR-27	63.8	75.2	96.7	99.5	9.4	13.6	14.7
S.Em.±	**1.26**	**1.62**	**1.56**	**1.65**	**0.26**	**0.25**	**0.25**
CD @ 5%	**3.64**	**4.68**	**4.51**	**4.75**	**0.75**	**0.72**	**0.72**
Interaction							
N_1V_1	63.5	73.3	96.1	97.4	9.0	13.3	15.4
N_1V_2	66.5	77.9	99.5	102.3	9.6	13.8	14.9

N_1V_3	77.7	89.2	110.6	113.6	8.6	12.8	13.8
N_1V_4	44.4	55.7	77.1	79.9	9.0	13.2	14.3
N_1V_5	58.3	69.7	91.3	94.2	9.4	13.7	14.8
N_1V_6	61.1	72.6	94.0	96.8	7.9	12.1	13.2
N_2V_1	63.5	74.8	96.3	99.1	9.4	13.6	14.7
N_2V_2	69.1	80.3	101.8	104.6	9.3	13.5	16.6
N_2V_3	81.2	92.3	113.9	116.7	10.5	14.7	15.7
N_2V_4	46.2	57.5	79.1	81.8	10.4	14.6	15.7
N_2V_5	59.7	71.1	92.6	95.4	11.2	15.4	16.4
N_2V_6	64.1	75.4	96.8	99.5	9.7	13.8	14.9
N_3V_1	67.8	79.2	100.7	103.5	11.5	15.7	15.9
N_3V_2	72.0	83.0	104.6	107.4	11.3	15.3	16.4
N_3V_3	82.8	94.2	115.7	118.8	9.9	14.1	16.9
N_3V_4	48.2	59.4	81.0	83.8	11.8	16.1	17.2
N_3V_5	66.3	77.5	98.9	101.8	11.8	16.0	17.0
N_3V_6	66.3	77.5	99.3	102.1	10.6	14.8	15.9
S.Em.±	**2.38**	**2.63**	**2.55**	**2.73**	**0.42**	**0.42**	**0.43**
CD @ 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

RDN: Recommended dose of nitrogen NS: Non significant

Table 2: Yield attributes of paddy as influenced by different treatments

Treatments	No of panicles per m^2	Panicle length (cm)	Panicle weight (g)	Filled grains per panicle	Unfilled grains per panicle	Grain filling percentage
Main plot: Nitrogen level						
N_1 : 100% RDN	525.8	21.8	3.38	123.7	15.4	88.8
N_2 : 125% RDN	582.8	22.0	3.49	134.9	13.1	91.2
N_3 : 150% RDN	586.3	22.9	3.64	146.9	11.7	92.6
S.Em.±	**6.00**	**0.34**	**0.04**	**1.06**	**0.76**	**0.46**
CD @ 5%	**23.5**	**NS**	**0.17**	**4.16**	**NS**	**1.82**
Sub plot: Varieties						
V_1 : CSR-36	559.8	22.3	3.32	148.2	11.7	92.6
V_2 : CSR-22	573.5	22.6	3.54	137.8	11.8	91.9
V_3 : CSR-23	549.2	24.1	3.39	117.8	11.3	91.2
V_4 : BPT-5204	550.1	19.5	3.33	144.1	22.2	86.7
V_5 : GGV-05-01	640.8	22.5	3.82	162.8	11.3	93.5
V_6 : CSR-27	516.2	22.3	3.62	100.3	12.2	89.1
S.Em.±	**16.72**	**0.39**	**0.07**	**2.11**	**1.31**	**0.91**
CD @ 5%	**48.29**	**1.12**	**0.19**	**6.09**	**3.81**	**2.63**
Interaction						
N_1V_1	573.2	21.7	2.63	139.4	15.3	90.1
N_1V_2	573.9	23.7	3.57	117.3	13.9	89.4
N_1V_3	502.9	23.7	3.31	103.8	11.1	90.3
N_1V_4	486.9	18.8	3.92	136.4	19.2	87.7
N_1V_5	561.9	21.2	3.88	152.0	15.6	90.7
N_1V_6	455.9	21.7	2.99	93.5	17.0	84.5
N_2V_1	537.1	22.0	3.52	145.1	11.1	92.8
N_2V_2	571.0	20.6	3.35	142.5	12.5	92.0
N_2V_3	554.4	23.8	3.59	110.6	9.7	91.9
N_2V_4	582.1	19.9	2.82	143.9	25.5	85.0
N_2V_5	676.8	22.3	3.77	164.3	8.6	95.0
N_2V_6	575.0	23.2	3.87	102.6	11.0	90.3
N_3V_1	569.2	23.1	3.80	160.1	8.7	94.8
N_3V_2	575.5	23.6	3.71	153.6	8.9	94.5
N_3V_3	590.4	24.8	3.27	138.9	13.0	91.5
N_3V_4	581.2	19.7	3.25	151.9	21.8	87.5
N_3V_5	683.6	24.1	3.81	172.2	9.6	94.7
N_3V_6	517.7	22.0	3.98	104.8	8.4	92.6
S.Em.±	**27.11**	**0.70**	**0.11**	**3.50**	**2.24**	**1.51**
CD @ 5%	**NS**	**2.20**	**0.35**	**10.45**	**NS**	**NS**

RDN: Recommended dose of nitrogen NS: Non significant

Table 3: Grain yield, straw yield and test weight of paddy as influenced by different treatments

Treatments	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield
Main plot: Nitrogen level			
N_1 : 100% RDN	19.9	4906	5969
N_2 : 125% RDN	20.2	5166	6402
N_3 : 150% RDN	20.0	5490	7147
S.Em.±	**0.33**	**57.39**	**52.19**
CD @ 5%	**NS**	**225.3**	**204.9**
Sub plot: Varieties			
V_1 : CSR-36	22.6	5504	6797
V_2 : CSR-22	22.1	5393	6759
V_3 : CSR-23	22.0	5030	6316
V_4 : BPT-5204	14.7	4285	5548
V_5 : GGV-05-01	15.5	5684	7052
V_6 : CSR-27	23.2	5228	6925
S.Em.±	**0.47**	**105.56**	**142.14**
CD @ 5%	**1.35**	**304.9**	**410.5**
Interaction			
N_1V_1	23.2	5393	6662
N_1V_2	21.6	5188	6276
N_1V_3	21.9	4607	5530
N_1V_4	13.5	3857	4733
N_1V_5	16.2	5327	6409
N_1V_6	23.0	5063	6204
N_2V_1	22.0	5493	6698
N_2V_2	22.4	5241	6430
N_2V_3	22.3	5198	6565
N_2V_4	14.7	4114	5248
N_2V_5	15.9	5758	6909
N_2V_6	23.3	5192	6204
N_3V_1	22.0	5626	7031
N_3V_2	22.3	5750	7571
N_3V_3	21.8	5285	6854
N_3V_4	16.0	4883	6662
N_3V_5	14.5	5967	7838
N_3V_6	23.3	5430	6562
S.Em.±	**0.81**	**176.50**	**230.73**
CD @ 5%	**NS**	**NS**	**NS**

RDN: Recommended dose of nitrogen NS: Non significant

CONCLUSION

Overall, the performance of GGV-05-01 in terms of grain and straw yield under saline soil was better (32.64 and 27.10 percent) than the BPT-5204 which is a highly preferred traditional rice variety of the region, respectively. The performances of CSR-36 and CSR-22 which are of medium slender nature were next to GGV-05-01.

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