Eco. Env. & Cons. 28 (October Suppl. Issue) : 2022; pp. (S220-S225)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i06s.037

Performance of hybrid rice (*Oryza sativa* L.) as influenced by nitrogen levels and biofertilizers

Gayathri Anamalagundam, Mamatha Rangani, Sreenivasa Chari Matla, V.P. Usadadiya*, P.B. Patel and Santhosh Kumar Naik B.

Department of Agronomy, N.M. College of Agriculture, Navsari Agricultural University, Navsari 396 450, Gujarat, India

(Received 14 February, 2022; Accepted 25 March, 2022)

ABSTRACT

A field study was conducted during summer season at Main Rice Research Station, Navsari to assess the performance of hybrid rice (*Oryza sativa* L.) as influenced by different N levels and biofertilizers under south Gujarat condition. The field trial was carried out in randomized block design with eight treatments (N_1: 80 kg N/ha, N_2: 100 kg N/ha, N_3: 120 kg N/ha, N_4: 140 kg N/ha, N_5: N_1 + *Azospirillum*, N_6: N_2 + *Azospirillum*, N_7: N_3 + *Azospirillum*, N_8: N_4 + *Azospirillum*) and three replications. Application of 140 kg N/ha in conjunction with *Azospirillum* produced significantly highest plant height, total tillers hill^{-1}, effective tillers hill^{-1}, LAI, CGR. The same treatment also attained highest length of panicle, panicles m^{-2}, panicle weight, grains panicle^{-1}, grain yield (4629 kg/ha), straw yield (5632 kg/ha) and harvest index of hybrid rice. The Grain and straw yields were increased to the tune of 123 and 72%, respectively with higher N level + *Azospirillum* (N_8) over lower N level and without *Azospirillum* (N_1), however, it was statistically at par with N_4 and N_7 with respect to grain yield. The treatments were failed to record any significant effect on the length of panicle and test weight. The highest economic benefit was recorded with the treatment N_8 over other tested treatments.

***Key words**: Hybrid rice, Bio-fertilizers, Nitrogen levels, Grain yield*

Introduction

Rice (*Oryza sativa* L.) belongs to gramineae family which is exhaustive in nature and requires lot of nutrients for its growth and development. Out of 43 million hectares of rice cultivated area, only 2.58 m. ha. land is under hybrid rice. Hybrid rice cultivation provides an additional yield benefit of 0.5 to 1 t/ha. Higher yield production require enormous addition of input fertilizers especially nitrogen. Nutrient supply to crop in the form of chemical fertilizers will impair both soil and environmental health and also responsible for the generation of green house gasses in adequate amounts (Stokstad, 2016).

Instead of using chemical fertilizers alone as a source of nitrogen, it is advisable to use a combination of bio-fertilizers with chemical fertilizers is better option to decrease the quantity and cost of chemical fertilizers (Singh *et al*., 2006). The use of bio-fertilizers increased recently at global level due to negative impact of excessive use of chemical fertilizers (Malusa and Vassilev, 2014).

Biological nitrogen fixation is a potentially attractive and alternate source of N (Rogers and Oldroyd, 2014), accounting 30-50% of the total nitrogen in the crop fields (Rosenblueth *et al*., 2018). Bio-fertilizers will encounter the effect of indiscriminate use of

(*Professor and Head)

chemical fertilizers, stimulate the growth of plant and also enhances the soil health, fertility and productivity status (Islam *et al*., 2012). Among all biofertilizers, *Azospirillum* is found to be associated with grass and cereal crops and it will fix atmospheric N in rice. Hence the present study was planned to find out the performance of hybrid rice (*Oryza sativa* L.) as influenced by different N levels and biofertilizers under south Gujarat condition to enhance the yield, soil health and fertility status on sustainable basis in the long run.

Materials and Methods

This field trial was carried out during summer season in 2019 at main rice research station farm, Soil and Water Management Research Unit, N.A.U., Navsari. Geographically, the farm has located at $20^0 10'$ N latitude, $73^0 20'$ E longitude and has an altitude of 10 m above the MSL. The soil was clayey in texture with pH 7.87, 0.4% O. C. (low O.C.), 0.45 dS/m EC, 199 kg available N/ha and 30.4 kg/ha of available P_2O_5. The hybrid rice (GRH 2) of 30 days aged seedlings (single seedling per hill) were transplanted with geometry of 20 x 15 cm on 29th January, 2019 and harvested on 10th June, 2019. The experiment was laid out in RBD with three replications. The treatments comprised of N_1: 80 kg N/ha, N_2: 100 kg N/ha, N_3: 120 kg N/ha, N_4: 140 kg N/ha, N_5: N_1 + *Azospirillum*, N_6: N_2 + *Azospirillum*, N_7: N_3 + *Azospirillum*, N_8: N_4 + *Azospirillum*.

Nitrogen was applied as per treatments in the form of urea in three split doses (40% at basal, 40% at tillering and 20% at P.I. stages). Bio-fertilizer *viz*., *Azospirillum* at the rate of 2 kg/ha were mixed with FYM and applied as per the treatments at transplanting. Basal application of 30 kg P_2O_5/ha was applied in the form of SSP as common. Growth attributes like plant height at 20, 40 DAT and at harvest, no. of tillers hill^{-1} and no. of effective tillers hill^{-1} at 75 DAT, LAI during 30, 60 and at 90 DAT and CGR at 30-60 and 60-90 DAT were recorded from five selected and tagged hills per plot and their average was worked out.

LAI and CGR were calculated by using following formulae.

$$\text{LAI} = \frac{\text{Leaf area}}{\text{Ground area}}$$

$$\text{CGR (g/ m}^2\text{/day)} = \frac{W2-W1}{P\ X\ (t2-t1)}$$

Where, W_1 and W_2 are dry weight of plants m^{-2} at times t_1 and t_2, respectively; P is land area.

Yield components *viz*., panicle length, panicles m^{-2}, weight of panicle, grains panicle^{-1}, test weight (1000 grain weight) were recorded at maturity from five tagged plants in each plot. After harvest, grain yield, straw yield and H.I. also registered. Harvest Index was computed by using following formula

$$\text{H.I. (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

Soil chemical status was analyzed by using various methods after crop harvest at a depth of 0-15 cm. Available nitrogen content of soil was determined by alkaline $KMnO_4$ method. Olsen's and flame photometric methods were used for the analysis of available P_2O_5 and K_2O content, respectively.

The economic benefit of hybrid rice was worked out by considering the prevailing market price of the inputs and outputs. BCR was calculated as follows:

$$\text{BCR} = \frac{\text{Gross income (Rs./□a)}}{\text{Total cost of cultivation (Rs./□a)}}$$

Data were analyzed statistically by using the method of analysis of variance (ANOVA) and tested by P- value at 0.05 level of probability and CD was worked out wherever the effects found significant.

Results and Discussion

Growth parameters

Application of 140 kg N/ha along with *Azospirillum* produced tallest plants with values of 25.8 and 100.1 cm at 20 DAT and at harvest, respectively, accounting 7% and 13% greater plant height than lower level of N alone, respectively (Table 1). While, it remained at par with N_2, N_3, N_4, N_6 and N_7 with respect to plant height at 20 DAT. The highest plant height at 40 DAT was produced under 120 kg N/ha + *Azospirillum*, however, it was statistically at par with N_3, N_6 and N_8. Fertilization of 140 kg N/ha + *Azospirillum* noticed more number of tillers and effective tillers hill^{-1} than other treatments, while; it was statistically at par with N_7. Total and effective tillers hill^{-1} were increased to the tune of 87 and 84%, respectively over 80 kg N/ha alone as chemical fertilizer (Table 1). LAI was registered highest with the treatments of N_4, N_8 at 30 DAT; N_8 at 60 DAT and with N_3, N_4, N_7 and N_8 during 90 DAT, however, treatment N_8 was at par with N_3, N_4 and N_7 at 60

DAT. Notably, N_8 (140 kg N/ha + *Azospirillum*) recorded significantly highest CGR at both 30-60 and 60-90 DAT compared to rest of the treatments, accounting 70% and 45% greater than 80 kg N/ha, respectively. While, at 60-90 DAT, it was statistically on par with N_7 (Table 1).

All measured growth attributes were observed highest with the application of higher N rate along with *Azospirillum*. Nevertheless, lower growth parameters were recorded under lower level of nitrogen without any bio-fertilizer addition.

The treatments with inoculation of *Azospirillum* along with chemical N fertilizer showed an additional benefit of all measured growth attributes over without *Azospirillum i.e.* N alone at same rates. All yield components and yields of hybrid rice also followed the similar trend. N plays a major role in enhancing the plant height due to its effect on vegetative growth and development. Pal *et al.* (2020) states that bio-fertilizers significantly improves the plant height and photosynthetic rate by fixing N content in soil. Maximum no. of tillers and effective tillers hill^{-1} observed with N_8 due to availability of adequate quantity of N for long period of time (Wijebandara *et al*. 2008).

LAI decreased gradually towards lower N rate. According to Watson (1947), leaf area typically increases after crop emergence to a maximum and then decline. CGR was highest at heading stage of the crop. LAI is an essential parameter to augment photosynthesis and plant productivity. Maximum LAI induces greater no. of tillers per hill and dry matter production leading to accumulation and translocation of photosynthates. These results are in conformity with Pal *et al*. (2020), Mathews *et al*. (2006).

Yield components

All measured yield components *viz*., No. of panicles m^{-2}, panicle weight and grains panicle^{-1} were considerably highest with N_8 compared to other tested treatments, accounting 47%, 71% and 44% greater over lowest yield components obtained treatment *i.e*., N_1, respectively. However, test weight and length of panicle were responded non-significantly among all treatments (Table 2). N fixing microbes supply considerable organic matter in addition to nitrogen. On other hand, bio-fertilizers (*Azospirillum*) provide the nutrients continuously throughout the life cycle of crop, which was reported by Rajeshwar, R. and Khan, A. A. M. (2010). Under favorable conditions, *Azospirillum* also secretes organic acids and some amount of growth promoting substances *viz*., Auxins, which in turn helps in production of more no. of tillers as well as panicles hill^{-1} and grains panicle^{-1} of the crop. These findings are in line with Islam *et al*. (2012), Tandel *et al*. (2013) and Tejaswini *et al*. (2017).

Yields and Harvest Index

Highest grain yield, straw yield and harvest index of rice were registered under treatment N_8 followed by N_7 (Table 3), however, N_6 also recorded same harvest index with N_8. Grain and straw yields of N_8

Table 1. Effect of different nitrogen levels and bio-fertilizers on growth attributes of hybrid rice

Treatments	Plant height (cm)			Total tillers hill^{-1}	Effective tiller hill^{-1}	LAICGR (g m^{-2} day^{-1})				
	At 20 DAT	At 40 DAT	At harvest			At 30 DAT	At 60 DAT	At 90 DAT	At 30-60 DAT	At 60-90 DAT
N_1	24.1	36.9	88.2	11.8	11.7	2.2	4.8	4.2	8.6	25.6
N_2	25.1	40.6	94.5	16.7	16.7	2.3	5.1	4.3	9.3	28.0
N_3	24.9	43.9	94.6	18.8	18.8	2.4	5.2	4.5	12.6	28.6
N_4	25.2	41.9	97.1	19.5	19.2	2.5	5.2	4.5	12.0	28.2
N_5	24.6	39.7	88.9	19.2	19.2	2.2	4.8	4.2	9.6	28.9
N_6	25.0	42.1	96.4	20.5	20.4	2.3	5.1	4.3	10.3	31.4
N_7	25.7	44.4	97.6	21.3	20.9	2.4	5.2	4.5	13.4	37.0
N_8	25.8	44.0	100.1	22.1	21.6	2.5	5.3	4.5	14.7	37.3
SE (m)	0.33	0.08	0.54	0.34	0.23	0.01	0.03	0.006	0.31	1.09
SE (d)	0.47	1.13	0.76	0.48	0.32	0.02	0.04	0.009	0.44	1.54
CD @5%	1.02	2.42	1.63	1.03	0.70	0.05	0.09	0.02	0.94	3.30

N_1: 80 Kg N/ha, **N_2:** 100 kg N/ha, **N_3**: 120 kg N/ha, **N_4**: 140 kg N/ha, **N_5**: N_1 + *Azospirillum*, **N_6**: N_2 + *Azospirillum*, **N_7**: N_3 + *Azospirillum*, **N_8**: N_4 + *Azospirillum*

Table 2. Influence of various N levels and bio-fertilizer on yield components of hybrid rice

Treatments	Panicle length (cm)	No. of panicles m^{-2}	Panicle weight (g)	Grains $panicle^{-1}$	Test weight (g)
N_1	21.5	206.0	2.1	142.3	19.0
N_2	21.8	214.3	2.4	169.0	19.0
N_3	22.0	259.3	3.1	181.3	19.1
N_4	22.0	261.0	3.1	184.7	19.1
N_5	22.3	210.7	2.4	153.7	19.0
N_6	22.4	271.7	3.1	178.3	19.1
N_7	22.3	271.3	3.2	202.3	19.1
N_8	22.5	304.0	3.6	205.0	19.1
SE (m)	0.20	3.13	0.04	3.44	0.04
SE (d)	0.28	4.42	0.05	4.86	0.06
CD @5%	NS	9.45	0.12	10.39	NS

N_1: 80 Kg N/ha, **N_2:** 100 kg N/ha, **N_3**: 120 kg N/ha, **N_4**: 140 kg N/ha, **N_5**: N_1 + *Azospirillum*, **N_6**: N_2 + *Azospirillum*, **N_7**: N_3 + *Azospirillum*, **N_8**: N_4 + *Azospirillum*

Table 3. Performance of hybrid rice as influenced by N levels and bio-fertilizers on yields

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index (%)
N_1	2069.1	3268.6	39.2
N_2	3416.5	4176.1	45.0
N_3	3939.0	5035.2	43.9
N_4	4362.7	5419.8	44.6
N_5	3482.4	4338.5	44.5
N_6	4038.2	4925.7	45.1
N_7	4405.0	5473.4	44.6
N_8	4629.3	5632.1	45.1
SE (m)	109.24	202.07	0.57
SE (d)	154.49	285.77	0.80
CD @5%	329.83	610.09	1.72

N_1: 80 Kg N/ha, **N_2:** 100 kg N/ha, **N_3**: 120 kg N/ha, **N_4**: 140 kg N/ha, **N_5**: N_1 + *Azospirillum*, **N_6**: N_2 + *Azospirillum*, **N_7**: N_3 + *Azospirillum*, **N_8**: N_4 + *Azospirillum*

Table 4. Effect of different N rates and bio-fertilizer on soil chemical status

Treatments	Available N (Kg ha^{-1})	Available P_2O_5 (Kg ha^{-1})	Available K_2O (Kg ha^{-1})
N_1	221.0	32.7	305.5
N_2	256.3	38.6	269.5
N_3	301.8	37.0	268.0
N_4	284.1	37.3	308.8
N_5	230.4	34.6	366.2
N_6	273.9	46.5	410.6
N_7	303.6	36.9	261.9
N_8	303.3	38.1	373.5
SE (m)	21.11	4.79	44.59
SE (d)	29.85	6.78	63.06
CD @5%	NS	NS	NS

N_1: 80 Kg N/ha, **N_2:** 100 kg N/ha, **N_3**: 120 kg N/ha, **N_4**: 140 kg N/ha, **N_5**: N_1 + *Azospirillum*,**N_6**: N_2 + *Azospirillum*, **N_7**: N_3 + *Azospirillum*, **N_8**: N_4 + *Azospirillum*

were increased to the tune of 123% and 72%, respectively compared to N_1. Garai *et al*., (2013) reported that, yield differences were due to differences in number of total and effective tillers per hill.

Azospirillum is known to synthesize growth substances like IAA, auxins and vit. B which might have also helped in increasing the plant height, no. of tillers, dry matter production and ultimately increase the yield. Fukami *et al*. 2018 stated that the main benefit of *Azospirillum* relies not only on auxins synthesis but also on cytokinins, gibberillins, abscissic acid, ethylene and salicylic acid synthesis. Phytohormones greatly influence root growth which resulting in better uptake of moisture and nutrients. Some researchers (Kim *et al*. 2012) also reported that, *Azospirillum* helps in mitigating abiotic stresses *i.e.* salinity and drought *etc.* by Induced Systemic Tolerance (IST). Bio-fertilizer application raised the crop yield by 0.5 to 1.49 t/ha. Similar result also has been reported by Praveen, K. V. and Singh, A. (2019). The above findings are in agreement with Nayak *et al.* (2003), Tejaswini *et al.* (2017) and Islam *et al*. (2012). Marlina *et al.* reported that, Bio-fertilizers contain microbes that are significant to improve crop growth this results in increased crop yields and sustainability.

Soil chemical parameters

As depicted in Table 4, various levels of nitrogen

Table 5. Economics of different treatments

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross realization (ha^{-1})	Cost of cultivation (ha^{-1})	Net returns (ha^{-1})	BCR
N_1	2069.1	3268.6	35667	31367.25	4300	1.13
N_2	3416.5	4176.1	55235	31611.12	23624	1.74
N_3	3939.0	5035.2	64343	31855.02	32488	2.01
N_4	4362.7	5419.8	70793	32098.97	38694	2.20
N_5	3482.4	4338.5	56546	32245.25	24301	1.75
N_6	4038.2	4925.7	65252	32489.12	32763	2.00
N_7	4405.0	5473.4	71483	32733.02	38750	2.18
N_8	4629.3	5632.1	74762	32976.97	41785	2.26

N_1: 80 Kg N/ha, **N_2**: 100 kg N/ha, **N_3**: 120 kg N/ha, **N_4**: 140 kg N/ha, **N_5**: N_1 + *Azospirillum*, **N_6**: N_2 + *Azospirillum*, **N_7**: N_3 + *Azospirillum*, **N_8**: N_4 + *Azospirillum* ;Selling price of rice grain= 12.5 kg^{-1}, Straw= 3 kg^{-1}

and bio-fertilizer (*Azospirillum*) were failed to show the remarkable differences with respect to all the soil chemical parameters. However, numerically higher values of soil available N, P_2O_5 and K_2O were registered in the treatments which were inoculated with *Azospirillum*. Rajeshwar, M. and Khan, M. A. A. (2010) states that, introduction of bio-fertilizers is necessary for improving the soil fertility and productivity besides reducing the expenditure on chemical fertilizers. The microbes containing biofertilizers may improve the fertilizer efficiency, soil fertility and health. Vessey (2003) states that, biofertilizer *i.e. Azospirillum* facilitates availability of nutrient, decomposition of organic matter and better rhizosphere environment which might have helps in augmenting the growth and yield of rice.

Economic benefit

Application of 140 kg N/ha along with *Azospirillum* achieved highest gross realization and net returns compared to rest of the treatments with the values of 74762 ha^{-1} and 41785 ha^{-1}, respectively followed by N_7(Table 5). Maximum BCR also recorded under same treatment (N_8) with the value of 2.26. Lowest N rate without bio-fertilizer found to be inferior over others. These results are in line with Mathews *et al*. (2006) and Tandel *et al*. (2013).

Conclusion

From the results of present investigation it can be concluded that higher economic yield of hybrid rice (cv. GRH 2) could be obtained with the application of 120 kg N ha^{-1} along with bio-fertilizer *viz.*, *Azospirillum* and common dose of 30 kg P_2O_5 ha^{-1} at basal during summer season under South Gujarat condition.

References

Fukami, J., Cerezini, P. and Hungria, M. 2018. *Azospirillum*: benefits that go far beyond biological nitrogen fixation. *AMB Express*. 8(73) : 1-12.

Garai, T. K., Datta, J. K. and Mondal, N. K. 2013. Evaluation of integrated nutrient management on *boro* rice in alluvial soil and its impacts upon growth, yield attributes, yield and soil nutrient status. *Archives of Agronomy and Soil Science*. 60(1) : 1-14.

Islam, M. Z., Sattar, M. A., Ashrafuzzaman, M., Saud, H. M. and Uddin, M. K. 2012. Improvement of yield potential of rice through combined application of biofertilizer and chemical nitrogen. *African Journal of Microbiology Research*. **6**(3): 745-750.

Kim, Y-C., Glick, B. R., Bashan, Y. and Ryu, C-M. 2012. Enhancement of plant drought tolerance by microbes. In: Aroca R (ed) *Plant responses to drought stress: from morphological to molecular features.* Springer Verlag, Berlin, pp: 383-413. ISBN 978-3-642-32653-0.

Malusa, E. and Vassilev, N. 2014. A contribution to set a legal framework for biofertilizers. *Applied Microbiology and Biotechnology*. **98**(15): 6599-6607.

Marlina, N., Gofar, N., Subakti, A. H. P. K. and Rahim, A. M. 2014. Improvement of rice growth and productivity through balance application of inorganic fertilizer and biofertilizers in Inceptisol soil of lowland swamp area. *Agrivita*. **36**(1): 48-56.

Mathews, D. V., Patiland, P. L. and Dasog, G. S. 2006. Effect of nutrients and biofertilizers on yield and yield components of rice in coastal alluvial soil of Karnataka. *Karnataka Journal of Agricultural Sciences*. 19(4) : 799-803.

Nayak, G. V., Kulkarni, J. H. and Shivaprasad, M. 2003. Effect of *Azospirillum* inoculation at different levels of nitrogen on paddy yield under hilly zone of Karnataka. *Karnataka Journal of Agricultural Sciences*. 16(4): 510-513.

Pal, S., Sana, M., Banerjee, H. and Lhungdim, L. 2020. Effectiveness of nitrogen and bio-fertilizer choice for improving growth and yield of hybrid rice (*Oryza sativa* L.) during dry season. *Oryza*. 57(4): 302-309.

Praveen, K. V. and Singh, A. 2019. Realizing the potential of a low-cost technology to enhance crop yields: evidence from a meta-analysis of biofertilizers in India. *Agricultural Economics Research Review*. 32: 77-91.

Rajeshwar, M. and Khan, M. A. A. 2010. Effect of biofertilizers on crop yield and soil available nutrients of rice and maize in alfisols of nagarjuna sagar left canal command area of Andhra Pradesh, India. *An Asian Journal of Soil Science*. 5(1): 200-203.

Rogers, C. and Oldroyd, G. E. D. 2014. Synthetic biology approaches to engineering the nitrogen symbiosis in cereals. *J. Exp. Bot*. 65: 1939-1946.

Rosenblueth, M., Ormeño-Orrillo, E., López-López, A., Rogel, M. A., Reyes-Hernández, B. J., Martínez-Romero, J. C., Reddy, P. M. and Martínez-Romero, E. 2018. Nitrogen fixation in cereals. *Frontiers in Microbiology*. 9: 1794.

Singh, F., Kumar, R., Pal, S. and Kumar, P. 2006. Sustainable production of scented rice (*Oryza sativa*) with manures and biofertilizers. *Annals of Agricultural Research New Series*. 27 (4): 412-413.

Singh, K. K., Singh, K., Singh, R., Singh, Y. and Singh, C. S. 2006. Response of nitrogen and silicon levels on growth, yield and nutrient uptake of rice (*Oryza sativa* L.). *Oryza*. 43(3): 220-223.

Stokstad, E. 2016. The nitrogen fix. *Science*. 353: 1225-1227.

Tandel, B. B., Patel, D. D., Thanki, J. D., Arvadia, M. K. and Jat, R. A. 2013. Response of biofertilizers in conjunction with inorganic fertilizers in *kharif* paddy. *AGRES- An International e-Journal*. 2(3): 342-351.

Tejaswini, M., Sreedevi, B., Akula, B., Kumar, B. A. and Singh, A. 2017. Effect of cultivars and biofertilizers on growth, yield and nutrient content of aerobic rice (*Oryza sativa* L.). *Environment and Ecology*. 35(4C): 3022-3027.

Vessey, J. K. 2003. Plant growth promoting rhizobacteria as biofertilizer. *Plant Soil*. 255: 571-586.

Watson, D. J. 1947. Comparative physiological studies on the growth of field crops. *Annals of Botony*. 11: 41-76.

Wijebandara, D. M. D. I., Dasog, G. S., Patil, P. L. and Hebbar, M. 2008. Effect of nutrient levels and biofertilizers on growth and yield of paddy under system of rice intensification (SRI) and conventional methods of cultivation. *Tropical Agricultural Research*. 20: 343-353.