Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2582-2845.8251

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2020) *8*(5), 40-46

Indian Journal of Pure & Applied Biosciences

Peer-Reviewed, Refereed, Open Access Journal

Research Article

Effect of Nitrogen and Phophorus Fertilizers on Yield and Nutrient Uptake by Machine Transplanted Rice under Mechanized System of Rice Intensification (MSRI)

P. Maheswara Reddy*, G. Krishna Reddy, G. Prabhakar Reddy, K.V. Nagamadhuri, B. Ravindra Reddy and P. Sudhakar

*Senior Scientist (Agronomy),

Agronomy Division, Regional Agricultural Research Station, Tirupati, Andhra Pradesh, India

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

Received: 12.07.2020 | Revised: 19.08.2020 | Accepted: 26.08.2020

ABSTRACT

Field trial was conducted during rabi, 2014-15 and 2015-16 at farmer's field at K. C. Peta village of Tirupati mandal of Chittoor district, Andhra Pradesh to study the effect of nitrogen and phosphotic fertilizer levels on yield and nutrient uptake of machine transplanted rice under mechanized system of rice intensification in Randomized Block Design with factorial concept replicated thrice with four Nitrogen levels (80, 120, 160 and 200 kg N ha^{-1}) and three phosphorus levels (40, 60 and 80 kg P_2O_5 ha^{-1}). Grain and straw yields were increased with increased levels of nitrogen during both the years. Maximum grain and straw yields were recorded with 200 kg N ha^{-1} which was comparable with 160 kg N ha^{-1} and significantly superior over 120 and 80 kg N ha^{-1}. Highest grain and straw yield was recorded with the application of 80 kg P_2O_5 ha^{-1} which was comparable with 60 kg P_2O_5 ha^{-1} and 40 kg P_2O_5 ha^{-1}. Maximum Nitrogen, Phosphorus and Potassium uptake by grain and straw was with 200 kg N ha^{-1} which was at par with 160 kg N ha^{-1} and significantly superior over 120and 80 kg N ha^{-1}. Uptake of NPK by grain and straw varied non significantly with phosphorus levels and their interaction with nitrogen during both the years.

Keywords: *Rice, Grain yield, Nitrogen, Phosphorus, Nutrient uptake and MSRI.*

INTRODUCTION

Rice is one of the most important cereal crops, which plays a key role in food security and important staple food for more than 50 percent population of the world. About 90 percent of the rice grown in the world is produced and consumed only in Asian countries and it supplies 50 to 80 per cent calories of energy to Asians (Vasudevan et al., 2014). Rice is a staple food for more than 65 per cent of the indian population and accounts for more than 42 per cent of food production (Senthil Kumar et al., 2016).

Cite this article: Reddy, P.M., Reddy, G.K., Reddy, G.P., Nagamadhuri, K.V., Reddy, B.R., & Sudhakar, P. (2020). Effect of Nitrogen and Phophorus Fertilizers on Yield and Nutrient Uptake by Machine Transplanted Rice Under Mechanized System of Rice Intensification (MSRI), *Ind. J. Pure App. Biosci. 8*(5), 40-46. doi: http://dx.doi.org/10.18782/2582-2845.8251

In Andhra Pradesh state, rice is the principal food crop cultivated in an area of 2.20 m ha with a production of 12.35 m t and productivity of 5.59 t ha^{-1} (Statistical Year Book, 2019). Among the factors affecting crop production, fertilizer is the single most important factor that plays a crucial role in yield increase, provided other factors are not limiting. Chemical fertilizer holds the key to the success of the crop production systems of Indian agriculture. Achieving higher productivity needs adoption of greater nutrient supply as the soils are low in organic matter and nutrient status. A higher output per unit area also demands considerable amounts of external inputs, such as fertilizers.

Major rice growing soils of India are deficient in nitrogen and it becomes star input in rice cultivation. Optimum dose of nitrogen fertilization plays a vital role in growth and development of rice plant. Its growth is seriously hampered when lower dose of nitrogen is applied, which drastically reduces yield. Nitrogen has a positive influence on the production of effective tillers per plant, yield attributes and grain yield. The effect of nitrogen on rice growth and grain productivity are derived from several bio-chemical, physiological and morphological processes in the plant system thus, limitation of this nutrient in the growth period causes reduction of dry matter accumulation and prevents grain filling and therefore increases the number of unfilled grains. Among the plant nutrients, after nitrogen, phosphorus is a major essential plant nutrient and key input for increasing crop yield (Dastan et al., 2012). The application of phosphorous fertilizer either in excess or less than optimum rate affects both yield and quality remarkably. Similarly, phosphorus is a major component in ATP, which is a major energy source for carrying photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration (Yuan, 2002). The application of nitrogen and phosphorus fertilizers either in excess or sub optimum rate affects both yield and quality of rice to remarkable extent, hence, proper management of crop nutrition is of immense importance (Moro et al., 2008). Hence, judicial use and management of nutrients improves and maintains soil fertility, while sustaining an economically viable and environment friendly agriculture that will meet the requirements of the future. So, it is essential to find out the optimum dose of nitrogen and phosphorus application for efficient utilization of these nutrients by the rice plants for achieving better yield.

Under Mechanized System of Rice Intensification (MSRI), rice crop tends to produce profuse tillering due to planting of relatively younger seedlings at wider spacing. But all the tillers produced are not becoming productive due to less conversion ratio and even the grain filling is poor in tertiary tillers which ultimately causing the reduction in grain yield. This may be attributed to inadequate nutrition and long assigned vegetative period, due to which nutrient hunger is more pronounced than conventional transplanting at recommended dose of nutrients. To avoid this starvation, due importance should be given to nutrient management under mechanized system of rice intensification. In traditional rice system, nutrient requirement studies are very well documented however, research work on nutrient management under MSRI is scanty and optimization of nutritional requirement for the machine transplanted crop is a research priority to sustain higher grain yields under MSRI. Hence, the present investigation is planned for optimization of nutrient requirements (N and P) for rice under machine transplanting.

MATERIALS AND METHODS

Field experiment was carried out during *rabi*, 2014-15 and 2015-16 at K. C. Peta village of Tirupati mandal of Chittoor district, situated at an altitude of 182.9 m above mean sea level at 13^{0}32'0" N latitude and 79^{o}24'25"E longitude in Southern agro climatic zone of Andhra Pradesh. The experimental soil was clay loam in texture, slightly alkaline in reaction (7.9), low in organic carbon, (0.51) and available nitrogen (216 kg ha^{-1}), high in available phosphorus (82 kg ha^{-1}) and available potassium (438 kg ha^{-1}). The experiment was laid out in Randomized Block Design with factorial concept with 4 Nitrogen levels (80, 120, 160 and 200 kg N ha^{-1}) and 3 phosphorus levels (40, 60 and 80 kg P_2O_5 ha^{-1}) replicated thrice. A common dose of 40 kg K_2O ha^{-1} was applied as basal dose to all the treatments. Entire P was applied basally as per treatment and N was applied in three equal splits at basal, 20 DAT and 40 DAT. Nursery was raised in plastic trays filled with the soil and press mud cake in 70:30 ratio and placed in raised beds. Foliar spray of 13-00-45 @ 0.5% was imposed at 10 DAS and machine transplanting was done at spacing 30 cm x 13-15 cm using 16 days old seedlings of NLR-34449, medium duration variety with Yanmar - VP8D transplanter. Individual plots were kept at 5.0 m length x 5.0 m width. Grains from net plot were threshed, cleaned, sun dried and weighed at 14 per cent moisture content and grain yield was calculated and expressed as kg ha^{-1}. After separating the grains, the left over straw from the net plot was sun dried and weighed. The straw yield was calculated and expressed as kg ha^{-1}. Pre-experimental composite soil samples were collected from 0-15 cm depth using core sampler to determine the physico-chemical properties. The post harvest soil samples collected from each plot after harvest of the crop were shade dried, powdered and sieved through 2.0 mm sieve for the analysis of available nutrients and were expressed in kg ha^{-1}. Plant and grain samples collected at harvest were oven dried and ground into fine powder in a willey mill and used for chemical analysis to estimate the uptake of N, P and K. The nutrient content of grain and straw was analysed and then multiplied with respective grain and straw yields to present the nutrient uptake at harvest and expressed in kg ha^{-1}. Nitrogen was estimated by modified micro kjeldahl method (Piper, 1966), phosphorus by Vanadomolybdo phosphoricyellow color method and potassium by flame photometry (Jackson, 1973).

$$\text{Nutrient uptake} = \frac{\text{Nutrient concentration (\%)}}{100} \times \text{dry matter} (\text{kg ha}^{-1})$$

RESULTS AND DISCUSSION

Effect on Grain and straw yield

Grain and straw yields were increased with increased levels of nitrogen. Maximum grain and straw yields were recorded with the application of 200 kg N ha^{-1} which was comparable with 160 kg N ha^{-1}. As compared to higher levels of nitrogen, application of 120 kg N ha^{-1} resulted in significantly lower grain and straw yield. Application of 80 kg N ha^{-1} recorded significantly lowest grain and straw yield. Inspite of the fact that the rice could not respond to phosphorus application and its interaction with nitrogen due to high initial soil available phosphorus, there was marginal increase in rice grain and straw yield, at higher levels of phosphorus application. Highest grain and straw yield was recorded with the application of 80 kg P_2O_5 ha^{-1} which was comparable with 60 kg P_2O_5 ha^{-1} and 40 kg P_2O_5 ha^{-1}

Nutrient Uptake

a. Nitrogen uptake

Nitrogen levels showed marked variations in nitrogen uptake by grain and straw during both the years. Levels of phosphorus and their interaction on nitrogen uptake was non significant during both the years. Application of 200 kg N ha^{-1} resulted in higher nitrogen uptake by grain and straw (115.5 and 51.4 kg ha^{-1}) which, however, did not vary significantly with 160 kg N ha^{-1} (107.6 and 48.5 kg ha^{-1}) during first year. As compared with the higher levels of nitrogen (200 and 160 kg N ha^{-1}), application of 120 kgN ha^{-1} (95.8 and 39.9 kg ha^{-1}) and 80 kg N ha^{-1} (81.8 and 32.9 kg ha^{-1}) resulted in significantly lower nitrogen uptake by grain and straw and significantly lowest nitrogen uptake was with the application of 80 kg N ha^{-1} during the first year. Similar trend in total nitrogen uptake (both grain and straw) was recorded. Increasing the N level from 80 to 120, 160 and 200 kg N ha^{-1} resulted in 14.0, 25.8 and

33.7 kg ha^{-1} higher nitrogen uptake by grain and 7.0, 15.6 and 18.5 kg ha^{-1} higher nitrogen uptake by straw respectively with the application of 120, 160 and 200 kg N ha^{-1} compared to the application of 80 kg N ha^{-1} during first year. During *rabi*, 2015-16 nitrogen uptake by rice in response to graded levels of nitrogen was similar to that of first year, except for marginal variations.

It is justifiable that at higher levels of nitrogen (160 and 200 kg N ha^{-1}), availability of nitrogen was more in soil and is absorbed more by the plants. Moreover, the uptake is the computation of N content and grain yield and hence, higher values were recorded by these two levels. These results are in accordance with the results of Nath et al. (2016), Dubey et al. (2016) and Murthy et al. (2015).

Phosphorus levels has not influenced nitrogen uptake by grain and straw and total uptake during first year. However, higher nitrogen uptake by grain and straw was recorded with 80 kg P_2O_5 ha^{-1} (104.8kg ha^{-1}) followed by 60 kg $P_2O_5ha^{-1}$ (98.1kg ha^{-1}) followed by 40 kg $P_2O_5ha^{-1}$ (97.6kg ha^{-1}). These results are in conformity with the findings of Nath et al. (2016) and Murthy et al. (2015). Similar trend in nitrogen uptake was recorded during second year. The interaction effect of nitrogen and phosphorus levels on nitrogen uptake by grain and straw was found to be non significant during both the years.

b. Phosphorus uptake

Phosphorus mobilization was higher in grain, when compared to straw with the application of different levels of nitrogen. Application of 200kg N ha^{-1} resulted in higher phosphorus uptake of 40.0 kg ha^{-1} by grain which was comparable with 160 kg N ha^{-1} (39.0 kg ha^{-1}) and significantly superior over the application of 120 kg N ha^{-1} (33.9kg ha^{-1}) and 80 kg N ha^{-1} (31.2 kg ha^{-1}) which remained at par with each other during first year. Increasing the N level from 80 to 120, 160 and 200 kg N ha^{-1} resulted in 2.7, 7.8 and 8.8 kg ha^{-1} higher phosphorus uptake by grain respectively, compared to the application of 80 kg N ha^{-1} during first year. Phosphorus uptake by grain has shown similar trend with the nitrogen application during the second year. Increased nutrient uptake especially N and P resulted in increased photosynthetic rate and increased plant growth. Increased photosynthetic rate resulted in higher translocation of nutrients to sink resulted in more grain yield as well as uptake.

The N levels played a marked role in P uptake by straw. Significant variations were observed in P uptake by straw. Among N levels compared, higher (20.2 kg ha^{-1}) P uptake in straw was recorded with the application of 200 kg N ha^{-1} which was comparable with 160 kg N ha^{-1} (18.0 kg ha^{-1}) and significantly superior over the application of 120 kg N ha^{-1} (16.3 kg ha^{-1}) and 80 kg N ha^{-1} (14.0 kg ha^{-1}). Application of 160 kg N ha^{-1} remained at par with 120 kg N ha^{-1} but, superior over 80 kg N ha^{-1} with respect to P uptake during first year. Similar trend in phosphorus uptake by straw was recorded with nitrogen levels during second year of study. Increasing nitrogen application stimulated more vegetative growth and increased foraging capacity of roots which in turn increased the uptake of phosphorus.

Non significant increase in phosphorus uptake by grain and straw was recorded due to the application of graded levels of phosphorus. However, higher phosphorus uptake by grain and straw (38.9 and 17.7 kg ha^{-1}) was with the application of 80 kg $P_2O_5ha^{-1}$ which was comparable with 60 kg $P_2O_5ha^{-1}$ (34.5 and 17.3 kg ha^{-1}) and 40 kg $P_2O_5ha^{-1}$ (34.6 and 16.3 kg ha^{-1}) during both the years. Similar results of higher phosphorus uptake with higher application of phosphorus was also reported by Nath et al. (2016) and Murthy et al. (2015). Interaction effect of nitrogen and phosphorus levels on phosphorusu ptake by grain and straw was found to be non significant during both the years.

c. Potassium uptake

The uptake of K by grain markedly differed due to nitrogen levels. Application of 200 kg N ha^{-1} recorded significantly higher K uptake (33.2 kg ha^{-1}), which was at par with 160 kg N ha^{-1} (31.6 kg ha^{-1}) and superior over other N levels i.e., 120 kg Nha^{-1} (28.1 kg ha^{-1}) and 80 kg N ha^{-1} (26.1 kg ha^{-1}) which remained at par with each other during first year. Application of 160 kg N ha^{-1}remained at par with 120 kg N ha^{-1} but, superior over 80 kg N ha^{-1} with respect to K uptake. Increasing levels of nitrogen from 80 to 200 $kgha^{-1}$ had contributed for gradual increment in uptake of K by grain. Potassium uptake by grain has shown similar trend with the nitrogen application during second year. The uptake of K was influenced by N levels to certain extent. This could be ascribed due to the synergistic effects of N and K up to certain level and beyond that level, there would be competition between N and K. This was also experienced by Norman et al. (2003) had the opinion that K uptake by grain would be smaller, when compared to N uptake by grain.

At maturity stage, the K uptake by straw increased with increased levels of nitrogen. The effect of N levels was much pronounced in the accumulation of K in straw. Highest K uptake by straw (160.2 kg ha^{-1}) was recorded with the application of 200 kg N ha^{-1} which was comparable with 160 kg N ha^{-1} (157.9 kg ha^{-1}) and significantly superior over the application of 120 kg N ha^{-1} (136.9 kg ha^{-1}) and 80 kg N ha^{-1} (119.6 kg ha^{-1}). Lower levels of nitrogen application (80 and 120 kg ha^{-1}) remained statistically at par with respect to K uptake by straw during first year of experimentation. Similar trend in potassium uptake by straw was recorded with nitrogen levels during second year of study. Increasing N levels promoted more vegetative growth and increased dry matter production ultimately, which is very common function ofnitrogen. These results are in accordance with the findings of Nath et al. (2016) and Murthy et al. (2015) who reported increased uptake of potassium by grain and straw with increased levels of nitrogen application.

Potassium uptake by grain and straw shown non significant increase due to the application of graded levels of phosphorus. However, higher potassium uptake by grain and straw (30.8 and 150.9 kg ha^{-1}) was recorded with the application of 80 kg $P_2O_5ha^{-1}$ which was comparable with 60 kg $P_2O_5ha^{-1}$ (27.4 and 142.2 kg ha^{-1}) and 40 kg $P_2O_5ha^{-1}$ (30.9 and 137.8 kg ha^{-1}) during both the years. Majumdar et al. (2005) explained that nitrogen had a complimentary effect on availability of other nutrients especially P and K thus enhanced uptake of nitrogen has resulted in enhancement in the uptake of phosphorus and potassium. Interaction effect of N and P levels on potassium uptake was found to be non significant during both the years.

Table 1: Nitrogen and Phosphorus uptake (kg ha^{-1}) by grain and straw of rice as influenced by nitrogen and phosphorus levels under MSRI during *rabi*, 2014-15 and 2015-16

Treatments	Nitrogen uptake (kg ha^{-1})						Phosphorus uptake (kg ha^{-1})					
	Grain		Straw		Total		Grain		Straw		Total	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Nitrogen levels (kg ha^{-1})												
N_1 : 80	81.8	82.7	32.9	36.2	114.7	118.9	31.2	31.0	14.0	14.7	45.2	45.7
N_2 : 120	95.8	97.6	39.9	41.5	135.7	139.2	33.9	34.2	16.3	15.5	50.2	49.7
N_3 : 160	107.6	110.1	48.5	49.7	156.1	159.8	39.0	39.1	18.0	17.3	57.0	56.4
N_4 : 200	115.5	117.9	51.4	53.1	166.9	170.9	40.0	39.7	20.2	18.8	60.2	58.6
SEm±	3.85	4.53	1.81	2.51	5.40	5.53	2.3	2.0	1.1	0.9	3.1	2.0
CD (P=0.05)	7.96	9.38	3.73	5.19	11.17	11.43	4.9	4.2	2.3	1.9	6.3	4.2
Phosphorus levels (kg ha^{-1})												
P_1 : 40	97.6	99.3	41.2	43.3	138.8	142.6	34.6	34.6	16.3	15.8	50.9	50.4
P_2 : 60	98.1	100.2	43.5	45.3	141.6	145.5	34.5	35.3	17.3	16.7	51.9	52.0
P_3 : 80	104.8	106.8	44.9	46.8	149.7	153.6	38.9	38.2	17.7	17.3	56.6	53.4
SEm±	3.33	3.93	1.56	2.17	4.67	4.79	2.0	1.7	1.0	0.8	2.6	1.7
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × P												
SEm±	6.66	7.85	3.13	4.35	9.35	9.57	4.1	3.5	2.0	1.6	5.3	3.5
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Potassium uptake (kg ha^{-1}) by grain and straw of rice as influenced by nitrogen and phosphorus levels under MSRI during *rabi*, 2014-15 and 2015-16

Treatments	Grain		Straw		Total		Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Nitrogen levels (kg ha^{-1})										
N_1 : 80	26.1	28.6	119.6	121.0	145.6	149.6	5532	5651	6179	6590
N_2 : 120	28.1	32.7	136.9	131.7	165.1	164.4	6383	6540	7198	7304
N_3 : 160	31.6	33.9	157.9	149.4	189.4	183.3	7063	7235	8187	8195
N_4 : 200	33.2	38.4	160.2	160.9	193.4	199.3	7527	7678	8382	8662
SEm±	2.0	2.5	9.3	7.0	10.1	8.4	259	232	321	269
CD (P=0.05)	4.2	5.3	19.1	14.5	20.8	17.4	535	480	663	556
Phosphorus levels (kg ha^{-1})										
P_1 : 40	30.9	31.4	137.8	133.0	168.7	164.4	6474	6631	7172	7439
P_2 : 60	27.4	34.3	142.2	142.8	169.7	177.1	6488	6657	7517	7662
P_3 : 80	30.8	34.5	150.9	146.4	181.8	180.9	6917	7039	7770	7963
SEm±	1.7	2.2	8.0	6.1	8.7	7.3	224	201	278	233
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × P										
SEm±	3.5	4.4	16.0	12.2	17.4	14.5	448	402	555	465
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CONCLUSION

In conclusion, the results revealed that, application of 160 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1} can be recommended for machine transplanted rice for realizing higher yields and returns for southern agro climatic zone of Andhra Pradesh under mechanized system of rice intensification. Application of 200 kg N ha^{-1} resulted in maximum nitrogen, phosphorus and potassium uptake by grain and straw however, varied non significantly with 160 kg N ha^{-1}. As compared with the higher levels of nitrogen (200 and 160 kg N ha^{-1}), application of 120 kg N ha^{-1} and 80 kg N ha^{-1} resulted significantly lesser nitrogen, phosphorus and potassium uptake by grain and straw. Uptake of NPK by grain and straw varied non significantly with phosphorus levels and their interaction with nitrogen.

REFERENCES

Dastan, S., Siavoshi, M., Zakavi, D., Ghanbaria–malidarreh, A., Yadi, R., Ghorbannia Delavar, E., & Nasiri, A. R. (2012). Application of nitrogen and silicon rates on morphological and chemical lodging related characteristics in rice (*Oryza sativa* L.) in north of Iran. *Journal of Agricultural Sciences 4*(6).

Jackson, M. C. (1973). *Soil Chemical Analysis*. Prentice - Hall of India Pvt. Ltd., New Delhi. 1-498.

Majumdar, B., Venkatesh, M. S., Kumar, K., & Patiram (2005). Nitrogen requirement for low land rice (*Oryza sativa*) in valley lands of Meghalaya. *Indian Journal of Agricultural Science. 75*, 504-506.

Moro, B. M., Nuhu, I. R., & Toshiyuki, W. (2008). Determining optimum rates of mineral fertilizers for economic rice grain yields under the "Sawah" System in Ghana. *West African Journal of Applied Ecology. 12*, 1.

Murthy, D. K. M., Upendra R. A., Vijay, D., & Sridhar, T. V. (2015). Effect of levels of nitrogen, phosphorus and potassium on performance of rice. *Indian Journal of Agricultural Research. 49*(1), 83-87.

Nath, S., Kumar, S., & Kannaujiya, S. K. (2016). Performance of various hybrids and fertility levels on yield attributes, yield and economics of hybrid rice (*Oryza sativa* L). *Journal of Krishi Vigyan*. *4*(2), 76-79.

Norman, R. J., Wilson, C. E., & Slaton, N. A. (2003). Soil fertilization and mineral nutrition in U.S. mechanized rice culture. In: Smith, C.W and Dilday, R.H. (eds). *Rice: Origin, history, Technology and Production*. John Wiley and Nyalemegbe 331-441.

Piper, C. S. (1966). *Soil and Plant Analysis*. Academic Press, New York.368.

Senthil Kumar, T., Radhamani, S., Kavitha, R., & Naik, R. (2016). Studies on mechanized transplanting and SRI method of rice cultivation. *Journal of Rice Research 9*(1), 43-46.

Statistical Year Book, (2019). *Directorate of Economics and Statistics*, Government of Andhra Pradesh, Hyderabad.

Vasudevan, S. N., Basangouda, Rakesh, C. M., Doddagoudar, S. R., & Shakuntala, N. M. (2014). Standardisation of seedling characteristics for paddy transplanter. *Journal of Advanced Agricultural Technologies 1*(2), 141-146.

Yuan, L. P. (2002). A scientist's perspective on experience with SRI in China for raising the yield of super hybrid rice. Cornell Institute for Food, Agriculture, and Development: http:// ciifad.cornell.edu/SRI: 23-25.