The Pharma Innovation Journal 2022; 11(12): 984-988

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 984-988

www.thepharmajournal.com
Received: 05-09-2022
Accepted: 07-10-2022

Bharti Parmar
Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Ekta Joshi
Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

RH Wanjari
ICAR-Indian Institute of Soil Science, Berasia Road, Nabi Bagh, Bhopal, Madhya Pradesh, India

Muneshwar Singh
ICAR-Indian Institute of Soil Science, Berasia Road, Nabi Bagh, Bhopal, Madhya Pradesh, India

Pragya Kurmi
Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Bharti Parmar
Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India

Effect of different doses of potassium on nutrient content, uptake and economics of rice (*Oryza sativa* L.) in vertisols of central India

Bharti Parmar, Ekta Joshi, RH Wanjari, Muneshwar Singh and Pragya Kurmi

Abstract
The field experiment was conducted during *Kharif* season of 2018-19 to evaluate the effect of different doses of potassium (K) on performance of rice crop. The experiment was laid out in Randomized Block Design (RBD) comprised of 4 doses of K *viz*., K_0 (0 kg K ha^{-1}) (control), K_{40} (40 kg K ha^{-1}), K_{80} (80 kg K ha^{-1}), K_{FP} (10 kg K ha^{-1}) with 3 replication under ongoing Long-Term Fertilizer Experiments (AICRP-LTFE) project at ICAR-Indian Institute of Soil Science, Bhopal (M.P.). The soil of the experimental site was Vertisols with the pH of 7.4 and EC 2.3 dS m^{-1} and organic carbon 0.77%. The data on nutrient content, uptake and economics of rice crop indicated significant influence of different doses of K treatments on crop *viz*., N (358.1 kg ha^{-1}), P (40.2 kg ha^{-1}), K (441.5 kg ha^{-1}) in soil. N (1.33 kg ha^{-1}), P (0.19 kg ha^{-1}), K (0.40 kg ha^{-1}) in grain and N (0.35 kg ha^{-1}), P (0.060 kg ha^{-1}), K (2.27 kg ha^{-1}) in stover with higher level of K dose (80 kg ha^{-1}), similarly the maximum uptake by grain, stover and total uptake by rice was recorded with 80 kg ha^{-1} of K application and was statistically at par with the application of K @ 40 kg ha^{-1}. Maximum grain yield (5495 kg ha^{-1}) and stover yield (6223 kg ha^{-1}) of rice attain with application of K @ 80 kg ha^{-1} and which was at par with 40 kg ha^{-1} K application. Therefore, the better growth and highest grain yield and stover yield of rice with application of K @ 80 kg ha^{-1} had fetched significant gross returns, net returns and B: C ratio compared to plot where no K was applied and farmers practice. The investigation proved that higher levels of K @ 80 kg ha^{-1} resulted in significant improvement in crop yield and also after reducing K dose from 80 to 40 kg ha^{-1} there was no major effect on yield of rice crop.

Keywords: Rice, potassium, nutrient, yield

1. Introduction

Rice has shaped the culture, diets and economic of millions of peoples, for more than half of the humanity "rice is life". Rice is a nutritional staple food which provides instant energy as its most important component is carbohydrate according to farmer.gov.in 2012. Increasing crop production while improving quality remains an important goal, particularly in the developing world. These developments make nutrient security together with food security a key global challenge. Among many factors, an adequate and well balanced nutrition with mineral nutrients is a fundamental issue in achieving a high crop production and a better quality in practical agriculture (Cakmak., 2010) [7]. The challenge in current Indian agriculture is not only to produce more food to feed the rapidly growing population but also to maintain soil health and quality by balanced fertilization. In India, rice is grown under diverse agro-ecological conditions such as irrigated (19.6 million hectare), rainfed upland (7.1 Mha), lowland (16.0 Mha) and deep water (1.5 m ha) (Moorthy and Mishra, 2004). In India, it is grown on 43.39 million hectare (Mha) with the production of 104.32 million tonnes (Mt) having average yield of 2404 kg ha^{-1} (DAC & FW, 2016) [9]. Soil fertility is decline mainly due to exceed removal of nutrients and inadequate replenishment through fertilizers and manures. In the scenario of decline land & water resources and increase in crop production will come about with increase the use of fertilizers. Plant absorbs K in large amount than any other mineral element except N. The K, which is contained in primary minerals is transferred slowly into available K and consequently available K at high fertilizer rates (Singh, 1984). Soil K can be partitioned into four different types based on its availability to plants. Solution K, exchangeable K, non-exchangeable K, and structural or mineral K are all in dynamic equilibrium with one another (Rahman *et al*. 2020) [26]. Solution and exchangeable K are thought to be quickly available, non-exchangeable K is thought to be slowly available, and mineral or structural K is thought to be the most difficultly available K form (Dasgupta *et al*. 2021) [10]. In contrast the benefit of N and P are more readily apparent at initial stage of crop growth. Many soils, initially sufficient in native supplies of soil potassium to raise a crop of 2 t ha^{-1} may need external supplies of K to produce a bigger crop of 3-4 t ha^{-1}. Currently in K deficient soils, fertilizer K is usually applied in amounts, which is a small fraction of the crop removal. Hence, the requirement of fertilizer K should increase proportionately more than that of N and P Kumari and Kumari (2014) [21]. Indian soils are now showing negative K balance to the tune of 10-12 Mt of nutrients in which K contributes to around 80%. Therefore, it is necessary to study the release pattern of K in soil to understand its response in different crops and soils. In soil potassium exists in several forms but major portion of soil-K exists as part of mineral structure and in a fixed or non-exchangeable form with a small fraction as water soluble and exchangeable K in soil (Reza *et al*. 2014) [28]. Hence, Lack of farmer's awareness about the importance of K indicates needs for more education. The inadequate use of K fertilizer may be lack of crop response of applied K, even on low K testing soils. Keeping in view the above background the study was conducted on Vertisols with the following objectives as

1. To assess the effect of different levels of potassium on growth and yield of rice.
2. To assess the effect of different levels of potassium on nutrient concentration & uptake by rice.
3. To work out economics of different potassium treatments.

2. Materials and Methods

A field experiment was carried out under the project initiated by Indian Institute of Soil Science (ICAR), Bhopal, during kharif season of 2018-19 for making a comparative study of the impact of graded doses of K on rice in Vertisols of Madhya Pradesh. It is situated at 23.10° N latitude and 77.20° E longitudes with an altitude of 500 m above the mean sea level. The climate of the experimental site is typically humid sub-tropical region characterized by fairly cool and dry winter, hot and dry summer and warm and humid monsoon. The mean maximum, and minimum temperature were 32.3 °C and 23.3 °C, respectively during crop growing period of rice. The mean annual rainfall is about 1146 mm, of which nearly 1020 mm is received during the monsoon period from July to September. The total rainfall received was 671.5 mm in *kharif* 2018 and mean relative humidity attains the maximum value (81.8%) during the south-west monsoon. It could be seen from the meteorological data that weather condition was congenial for growth and development of rice crop. Soil of the Farm belongs to order Vertisols having clay loam texture, medium to deep and black in color. The experiment was conducted in fixed plots in a Randomized Block Design. The entire experimental area at the farmers' field was divided into 6 sampling blocks representing the replications to reduce soil heterogeneity. Each block was divided into 4 unit plots with raised bunds as per treatments with different potassium doses *viz*., 0, 40, 80 Farmers practices. In farmers' practice N, P and K were applied @ 100, 50 and 10 kg ha^{-1} respectively. N and P were applied @120 and 60 kg ha^{-1} in all the treatments uniformly except K. Pusa Basmati-1 variety was used prepared a well pulverized nursery bed it was tilled with the help of tractor driven tyne cultivator followed by two harrowing with disc harrow.

Representative soil samples from 0 to 15 cm depth were drawn pior to the start of experiment and samples from each experimental plot were also collected after the harvest of the crop. Collected samples were air dried in shade, powdered and passed through 1 mm sieve and were analyzed for organic carbon (Jackson 1973), available N (Subbiah and Asija, 1956), available P (Olsen *et al*., 1954), available K (Jackson, 1950). Nutrient contents at harvest in the plant were determined dried from samples. N from plant samples was analyzed by using Kjeldahl's apparatus (Piper, 1966). The plant samples were digested in di-acid mixture (HNO_3 and $HClO_4$ in the ratio of (10:3) and P content was determined by using Vanado-molybdo-phosphoric acid yellow color method (Piper, 1966). The K content was determined by using the flame photometer (Jackson, 1950). The uptake of nutrients was computed by multiplying grain/straw yield of rice by their respective nutrient concentrations. The grain and straw yield were recorded at harvest. To evaluate the effectiveness and profitability of the treatments, comprehensive economics including cost of cultivation, gross returns, net returns ha^{-1} and B: C ratio was calculate. To arrive at a relevant conclusion, the experimental data collected for the various factors under study were statistically analyzed using Gomez and Gomez's ANOVA (1984). The variation in the treatments mean was examined using Least Significant Difference (LSD) values at a 5% level of significance.

3. Results and Discussion

3.1 Available nutrient content in soil

Data on available nutrient as affected by different K treatments are presented in Table.1. The data indicated that various K treatments varied significantly with graded doses of K in rice crop. The highest value of available N (358.1 kg ha^{-1}) was recorded with K @ 80 kg ha^{-1} in soil and found no significant effect of different doses of K. Similarly P found no significant effect of different doses of K and medium to high range in all the treatments. The K status in soil found to be in medium to high range. Available K in soil significantly differ from different doses of K and highest available K (441.5 kg ha^{-1}) found in 80 kg $ha^{-1}$of K application which was at par with 40 kg K ha^{-1} (405.8 kg ha^{-1}). Surekha and Narayana Reddy (2000) [32] reported that the moderate supply of K (40 kg K_2O ha^{-1}) along with N and P fertilizers ensured the depletion of soil available K in treatment receiving only N and P indicated the need for balanced application of NPK fertilizers under rice cropping.

Table 1: Effect of potassium application on available soil nutrients status (kg ha^{-1}) in rice crop (after harvest)

Treatments	Available N	Available P	Available K
K_0	354.2	36.4	329.3
K_{40}	357.4	39.4	405.8
K_{80}	358.1	40.2	441.5
K_{FP}	356.5	37.2	338.4
SEm±	14.501	1.2	14.0
CD at 5%	Non-significant	Non-significant	42.3

3.2 Nutrient concentration in rice grain and stover

Data pertaining to N, P and K concentration at harvest in grain and stover was affected by the graded doses of K in rice (Table 2). The N concentration in grain at harvest was found non-significant. The highest (1.33%) N concentration was recorded with @ 80 kg ha^{-1} K followed by 40 kg ha^{-1} K application and farmers' practice. However, the P and K concentration in grain at harvest was significantly higher with different doses of K doses. The application of 80 kg ha^{-1} of K resulted in the highest concentration of P (0.19%) and K (0.40%) and it was at par with K application @ 40 kg ha^{-1} and significantly superior to K_0 and farmers parctice. The application of graded doses of K doses in rice crop resulted in significantly effect on K concentration in stover but had no significant effect on N & P concentration in stover at harvest. The application of higher dose of K application (80 kg ha^{-1} K) found highest K (2.27%) in stover and it was at par with 40 kg K ha^{-1} (2.17). The lowest effect of K doses in rice crop found in control treatment where no K was applied.

Table 2: Effect of treatments on nutrient contents (%) in rice grain and stover

Treatments	N, P, K in grain			N, P, K in stover		
	N	P	K	N	P	K
K_0	1.21	0.14	0.34	0.32	0.052	1.64
K_{40}	1.31	0.16	0.38	0.34	0.057	2.17
K_{80}	1.33	0.19	0.40	0.35	0.060	2.27
K_{FP}	1.26	0.15	0.36	0.33	0.053	1.91
SEm±	0.045	0.0112	0.006	0.010	0.0021	0.104
CD at 5%	NS	0.036	0.019	NS	NS	0.315

3.3 Nutrient uptake in rice grain and stover

Similar to nutrient concentration in grain and stover the nutrient uptake by grain stover as well as total uptake by rice had also influence significantly with the graded doses of K application (Table 3). The N uptake by grain (72.7 kg ha^{-1}) and stover (21.5 kg ha^{-1}) was recorded maximum with 80 kg ha^{-1} of K application and was statistically at par with the application of K @ 40 kg ha^{-1}. But for total N uptake (94.2 kg ha^{-1}) the application of 80 kg h^{-1} of K resulted significantly superior compare to rest of the treatment. The highest P uptake by grain (10.38 kg ha^{-1}), straw (3.70 kg ha^{-1}) and total P uptake (14.1 kg ha^{-1}) was recorded with 80 kg ha^{-1} of K application but was at par with 40 kg ha^{-1} of K application. Similarly to N uptake the minimum P uptake by grain, stover and total uptake was recorded in control treatment (0 kg K ha^{-1}). Singh *et al*. (1999) [30] also reported the experiment that the uptake of K by grain and straw of rice significantly increased with increase in K application, however the application of K @ 80 kg ha^{-1} had recorded with significantly maximum uptake of K by grain (21.7 kg ha^{-1}), straw (141.0 kg ha^{-1}) and total K uptake (162.7 kg ha^{-1}) at harvest and was followed by 40 kg ha^{-1} of K application and farmers' practice. Singh and Wanjari (2012) [31] reported that rice crop in long term fertilizer experiments (LTFE) in India in the Vertisols also started showing response to applied K due to higher uptake than applied amount.

Table 3: N, P and K uptake (kg ha^{-1}) by rice grain after application of different K treatments

Treatments	Nitrogen			Phosphorus			Potassium		
	Straw uptake	Grain uptake	Total N uptake	Stover uptake	Grain uptake	Total P Uptake	Stover uptake	Grain uptake	Total K uptake
K_0	15.0	43.4	58.3	2.44	4.68	7.1	77.3	11.6	88.9
K_{40}	19.2	60.9	80.1	3.24	7.88	11.1	122.4	17.8	140.2
K_{80}	21.5	72.7	94.2	3.70	10.38	14.1	141.0	21.7	162.7
K_{FP}	17.0	51.7	68.7	2.74	6.53	9.3	99.5	15.2	114.8
SEm±	1.01	3.92	4.59	0.135	0.81	0.82	7.31	1.12	8.02
CD at 5%	3.30	11.81	13.84	0.406	2.43	2.46	22.02	3.39	24.16

3.4 Yield and economics of rice

The application of K @ 80 kg ha^{-1} resulted in the maximum grain yield (5495 kg ha^{-1}) of rice crop and was at par with K application @ 40 kg ha^{-1} (4671 kg ha^{-1}). The lowest grain yield was recorded with control plot (3412 kg ha^{-1}) and it was at par with farmers' practice (4258 kg ha^{-1}). Both the 80 & 40 kg ha^{-1} doses of potassium were significantly superior compare to farmers' practice. Similarly to grain yield the maximum stover yield was recorded with application of K @ 80 kg ha^{-1} (6223 kg ha^{-1}) and it was at par with 40 kg ha^{-1} K application (5632 kg ha^{-1}). The result revealed that the lowest stover yield was recorded with 0 kg ha^{-1} (4659 kg ha^{-1}) of K and was at par with 10 kg ha^{-1} of K application (5207 kg ha^{-1}). However, the harvest index had not influenced significantly with graded dose of K, but the highest value of HI was obtain with 80 kg ha^{-1} K application (46.7%) and was followed by 40 kg ha^{-1} K (45.2%) and farmers' practice (45.1%). Lowest HI was recorded with control plot (45.1%). Muthukumararaja *et al*. (2009) [24] resulted that addition 50 kg K_2O ha^{-1} recorded higher grain and straw yield in rice. The application of K at the rate of 80 kg ha^{-1} resulted in significantly highest returns (115930 ₹ ha^{-1}), net returns (73828 ₹ ha-$^{-1}$) & B:C ratio (1.75) compare to all other treatments but was at par with the treatment where K was applied @ 40 kg ha^{-1}. The farmers' practice resulted is the highest gross and net returns but it fetched significantly higher B:C ratio (1.23) compare to the plot where no K was applied.

Table 4: Effect of K on Grain yield, stover yield, harvest index and Profitability of rice cultivation

Treatments	Grain Yield (kg ha^{-1})	Stover Yield (kg ha^{-1})	Harvest index (%)	Gross returns (Rs. ha^{-1})	Net profit (Rs. ha^{-1})	Benefit : Cost ratio
K_0	3412	4659	42.2	74369	33879	0.83
K_{40}	4671	5632	45.2	99578	58282	1.41
K_{80}	5495	6223	46.7	115930	73828	1.75
K_{FP}	4258	5207	45.1	90994	50303	1.23
SEm±	296.6	248.2	1.262	5772.5	5772.5	0.140
CD at 5%	894.0	784.2	Non-significant	174004	17400.2	0.420

4. Conclusion

The population increase rapidly as well as demad of food grain increasing. To fulfill demand of food it is necessary to increase production. Results indicated that different levels of K fertilizer significantly influenced the nutrient concentration, uptake and soil nutrient content of Pusa basmati-1 rice variety. The highest amount of nutrients found with different doses of K. Furthermore, nutrient uptake by grain and straw differed in different treatments. Thus, K @ 80 kg ha^{-1} found to be beneficial in boosting crop productivity of rice cv. Pusa $basmati^{-1}$.

5. Acknowledgement

The financial support given by Indian Council of Agriculture Research (ICAR), New Delhi and International Potash Institute (IPI)-Gurgaon, India is duly acknowledged.

6. References

1. Aghimien EA, Osemwota IO. Distribution of potassium forms in some surface soils of Southern Nigeria. Nigerian Journal of Soil Science. 2010;20(1):122-127.
2. Al-Zubaidi A, Bashour I, Darwish T, Safieddin M. Content of different forms of potassium in Lebanese soils. International Potash Institute, No. 28; c2011.
3. Bahmaniar MA, Ranjbar GA, Ahamafian SH. Effect of N and K application on agronomic characteristics of two Iranian and landrace rice (*Oryza sativa* L.) cultivars, Pakistan Journal Biological Science. 2007;10(6):880-886.
4. Bhamanya MA, Ranjabar GA. The Role of Potassium in Improving Growth Indices and Increasing Amount of Grain Nutrient Elements of Wheat Cultivars. Journal of Applied Sciences. 2008;8(7):1280-1285.
5. Black CA, Evans DD, Ensminger LE, White JL, Clark FE. Methods of soil analysis (eds.). American Society of Agronomy. Madison, Winscousin. Agronomy (ASA); c1965. p. 09.
6. Brhane H, Mamo T, Teka K. Optimum potassium fertilization level for growth, yield and nutrient uptake of wheat (*Triticum aestivum*) in Vertisols of Northern Ethiopia. Soil & crop sciences. 2017;48(3):134-7022.
7. Cakmak I. Potassium for better crop production and quality. Plant Soil. 2010;335:1-2.
8. Chandrasekhararao C, Krishnamurthy V. Quantity-intensity relationship of potassium in flue-cured Virginia tobacco soils of Khammam district, Andhra Pradesh. Journal of the Indian Society Soil Science. 2007;55(2):212-215.
9. DAC & FW, Agricultural Statistics at a glance. Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics and Statistics; c2016. (http/www.agricoop.nic.in).
10. Dasgupta S, Sengupta S, Saha S, Saha N, Bhattacharyya K, Dey P. Predicting the response of soil potassium to broccoli (*Brassica oleracea* var. Italica) in a gangetic Inceptisol of West Bengal, India through suitable chemical extractants. Journal of Plant Nutrition. 2021;44(7):931-45.
11. Dwivedi AK, Singh Muneshwar, Kauraw DL, Wanjari RH, Chauhan SS. Research Bulletin on 'Impact of Fertilizer and Manure Use for Three Decades on Crop Productivity and Sustainability and Soil Quality under Soybean-Wheat System on Vertisol in Central India'. Indian Institute of Soil Science, Bhopal; c2007. p. 1-51.
12. Egilla JN, Davies FT, Drew MC. Effect of potassium on drought resistance of *Hibiscus rosasinensis* cv. Leprachaun: plant growth, leaf macro-and micronutrient content and root longevity. Plant Soil. 2001;229:213-224.
13. Fisher RA. On the Mathematical Foundations of Theoretical Statistics, Philosophical Transactions of the Royal Society, Ser. A. 1950;222:309-368.
14. Gangopadhyay SK, Sarkar Dipak, Sahoo AK, Das K. Forms and Distribution of Potassium in Some Soils of Ranchi Plateau. Journal of the Indian Society Soil Science. 2005;53(3):413-415.
15. Jatav MK, Manoj Kumar Dua, Sushil Kumar VK, Trehan SP. Distribution of different forms of potassium in potato growing soils of Jalandhar district of Punjab. International Journal of Agricultural and Statistical Sciences. 2014;10(1):175-179.
16. Kaliha U, Oiha J, Talukdar MC. Effect of levels and time of potassium application on yield and yield attributes of upland rice. Assam (India) Journal of Potassium Research. 1995;11(2):203-206.
17. Khan R, Gurmani AR, Gurmani AH, Zia SM. Effect of potassium application on crop yield under wheat rice cropping system. Sarhad Journal of Agriculture. 2007;23:277-279.
18. Krishnappa M, Gowda KN, Shankarnarayan V, Maharudrappa K, Khan MM. Effect of graded levels and split application of potassium on its availability and yield of rice. Journal of Potassium Research. 2006;6(4):156-161.
19. Kumar B, Sharma GK, Mishra VN, Pradhan A, Chandrakar T. Assessment of Nutrient Deficiencies Based on Response of Rice (*Oryza sativa* L.) to Nutrient Omission in Inceptisols of Kondagaon District of Chhattisgarh in India International Journal of Current Microbiology and Applied Sciences; c2018. ISSN: 2319-7706.
20. Kumar U, Mishra VN, Kumar N, Dotaniya CK, Mohbe S. Comparative study of soil quality indicators for rice-based cropping system in Vertisols of central plain of Chhattisgarh; c2018. DOI: 10.15740/HAS/AJSS/13.2/36-147)
21. Kumari Madhavi, Kumari Nisha. Depth wise distribution of potassium under various nutrient management practices in rice-wheat cropping system. Environment and Ecology. 2014;32(1):51-55.
22. Liao YL, Lu YH, Xie J, Yang ZP, Zhou X, Nie J. Effect of long term application of K fertilizer and rice straw on yields, crop potassium uptake and soil K supply capacity in double rice cropping system on Reddish soils. International Potash Institute. 2018;52:1-10.
23. Majumdar Kaushik, Anil Kumar, Vishal Shahi, Satyanarayan T, Jat ML, Dalip Kumar, *et al*. Economics of potassium fertilizer application in rice, wheat and maize grown in the Indo-Gangetic plains. Indian Journal Fertilizer. 2012;8(5):44-53.
24. Muthukumararaja T, Sriramachandrashekharan MV, Ravichandran M. Growth and sink potential of rice as influenced by sulphur and potassium fertilization. Plant Archives. 2009;9:83-85.
25. Odyuo Ekonthung, Sharma YK, Sharma SK. Potassium fraction of soils of SASRD Research farm of Nagaland University. Journal of the Indian Society of Soil Science.

2015;63(2):181-185.
26. Rahman MS, Khatun M, Topu MAA, Alam ABMS, Sarker A, Saleque MA. Potassium release and fixation in old Brahmaputra and Ganges tidal floodplain soils of Bangladesh. International Journal of Natural and Social Sciences. 2020;7(1):40-54.
27. Ravichandran M, Sriramachandrsehekaran MV. Optimizing timing of potassium application in productivity enhancement of crops. Karnataka J Agric. Sci. 2011;24(1):75-80.
28. Reza SK, Utpal Baruah, Chattopadhyay T, Sarkar Dipak. Distribution of forms of potassium in relation to different agro-ecological regions of North-Eastern India. Archives of Agronomy and Soil Science. 2014;60(4):507-517.
29. Richardson AD, Duigan SP, Berlyn GP. An evaluation of noninvasive methods to estimate foliar chlorophyll content. New Phytologist. 2002;153:185-194.
30. Singh D, Singh V, Singh R. Response of rice to nitrogen and potassium levels in alluvial soil. Journal of Potassium Research. 1999;15(1-4):88-92.
31. Singh Muneshwar, Wanjari RH. Potassium responses and requirement of crops grown in Vertisols: Experiences from Long Term Fertilizer Experiment. Indian J Fertilisers. 2012;8(3):26-32.
32. Surekha K, Narayana Reddy M. Response of hybrid rice to potassium application. Oryza. 2000;38(3&4):112-115.
33. Watson DJ. Comparative physiological studies in the growth of field crops. I. Variation in net assimilation rate and leaf area between species and varieties and within and between years. Annals of Botany. 1953;11:41-76.