Agric Res J **58** (5) : 789-793, *October* 2021
DOI No. 10.5958/2395-146X.2021.00112.5

GRAIN YIELD, ECONOMICS AND DISEASE SEVERITY OF RICE (*Oryza sativa* L.) IN RESPONSE TO FOLIAR APPLICATION OF POTASSIUM NITRATE

Buta Singh Dhillon[1]*, Gaurav Khosla[2], Tarvinder Pal Singh[2] and Jagjeet Singh Lore[1]

[1]Department of Plant Breeding and Genetics, [2]Office of Director (Seeds), Punjab Agricultural University, Ludhiana -141 004, Punjab

ABSTRACT

Keeping in view the physiological role of potassium and nitrogen in alleviating various stresses and reported yield improvement thereof, investigations were planned to study the effect of foliar application of potassium nitrate (13:0:45) on growth, yield, disease severity and economics of paddy. Investigations included three experiments over two years with five rice genotypes of varying maturity duration and grain number. Study revealed that foliar spray of potassium nitrate(1.0, 1.5 and 2.0 per cent) at boot stage caused numerical gain in number of filled grains per panicle as well as spikelet fertility (per cent), leading to improvement in grain yield of PR 124 and PR126 to the tune of 1.4 to 1.8 and 1.9 to 3.0 q ha^{-1}, respectively. Another study comprised two factors i.e. application stage (Boot, Anthesis, Boot + Anthesis) and potassium nitrate concentration (Control, 1.0, 1.5, 2.0 and 2.5 per cent). Application stages had no significant effect on yield, yield attributes and disease severity but application at boot stage was found promising as it gave highest net returns. Data also suggested that foliar spray of potassium nitrate @ 1.5 percent induced improvement in grain yield of PR 128 (4.1 q ha^{-1}), PR 129 (3.2 q ha^{-1}) and PR 121 (3.7 q ha^{-1}) over control (water spray) by way of improvement in spikelet fertility and panicle weight. Similarly, net returns with 1.5 per cent potassium nitrate spray were higher than control (water spray) by a margin of Rs. 3735 to 6339 per ha^{-1}. Potassium nitrate spray did not affect the severity of rice diseases(grain discoloration, false smut and brown spot). It is therefore suggested that foliar spray of potassium nitrate @ 1.5 per cent at boot stage enhanced productivity and net returns particularly in varieties having more grain number per panicle.

Keywords: Grain weight, Potassium nitrate, Rice, Spikelet fertility, Yield

Rice (*Oryza sativa* L.) is staple eating routine of more than 60 per cent of the global population and source of about 26.2% caloric intake (FAO, 2018). India is a major producer and consumer of rice after China (FAO, 2018).The global population is predicted to reach 9 billion and food requirements are projected to increase by 70–100 per cent by 2050 (FAO ,2017, Huang *et al.,* 2017). However, the shrinking natural resources and climate volatilities pose a great upcoming challenge to attain desirable production of rice. Moreover, the chance of increasing area under rice cultivation seems remote; enhancing productivity is the only alternative to augment the rice production, by adoption of suitable production technologies to overcome the factors limiting crop yield.

Paddy crop experiences various biotic and abiotic stresses including diseases, insect-pest, nutrient deficiency, high temperature and water stress at critical stages, etc. leading to lower productivity on account of lowered spikelet fertility and grain weight ,etc. Various reports reveal that grain filling (fertility) and grain weight are major yield contributing traits in rice, which are genetically controlled (Dingkuhn *et al.,* 2017), besides being influenced by environmental and agronomic practices (Maruyama *et al.,* 2013). It has been reported that deficiency or excess of mineral nutrients as well as application of nitrogen (N) late in the season is known to cause sterility, hence yield loss in paddy (Jahan *et al.,* 2014). Farmers are applying high doses of nitrogen and phosphatic fertilizers but ignoring the other nutrients including potassium (Singh *et al.,* 2005). The mining of potassium (K) is more intensive in states like Punjab because of intensive agriculture and burning of rice straw (Singh *et al.,* 2003).Potassium, although is not a component of any biomolecule in plants but plays significant role in plant growth and development throughout the life cycle of plant. It is a major component of protein synthesis, enzyme activity, pH gradient, phloem uploading, turgor pressure maintenance, stomatal functioning, ion balance and stress tolerance (Wang *et al.,* 2013).Exogenous potassium application is well established for aiding nutrient uptake, water use efficiency, photosynthesis and growth performance, carbohydrate distribution and starch synthesis in storage organs, which in turn results in higher grain yield (White *et al.,* 2012).

Punjab farmers are usually applying excessive dose of N(Khajuria, 2016), but that N is applied in the early phase of plant growth i.e. up to 6 weeks after

*Corresponding author : bsdhillon@pau.edu
Date of receipt: 03.05.2020, Date of acceptance: 28.07.2020

transplanting. Sometimes due to higher requirement of nitrogen during reproductive phase of paddy, plant shows mild N deficiency at later stages of grain growth. However, foliar application of small amount of N at later stages of crop growth can benefit the crop by delaying senescence. So keeping these facts in view, present investigations were planned to study the effect of foliar application of potassium nitrate (13:0:45) on growth, yield, disease severity and economics of paddy under Punjab conditions.

MATERIALS AND METHODS

Field experiments were conducted during *kharif* 2018 and 2019 at Research Farms of Punjab Agricultural University (PAU), Ludhiana, India [30°56' N latitude; 75°52' E longitude; 247 m altitude] located in the Indo–Gangetic Plain Region (IGPR). Climate of experimental site was characterized as subtropical, semi–arid with an average annual rainfall of 759 mm, out of which about 80 per cent is received from June to September (Prabhjyot-Kaur *et al.,* 2016). The soil of locations selected for conducting experiment was Typic Ustipsamment (Fatehpur sandy–loam) in texture, low in available N status and high in available– P but medium in available–K and soil organic carbon status. The soil pH and electrical conductivity were within the normal range.

Experiments were conducted at Research farm of Rice Section, Department of Plant Breeding & Genetics, PAU, Ludhiana for two consecutive years (*kharif* 2018 and 2019) and Seed Technology Research area, PAU, Ludhiana during *kharif* 2019. During 2018, five foliar spray treatments were imposed at boot stage. The treatments included Potassium nitrate sprays @ 1.0, 1.5 and 2.0 %, water spray and unsprayed. During 2019, the studies were conducted with different potassium nitrate sprays (control, 1.0, 1.5, 2.0, 2.5% and control i.e. water spray) along with variable application times i.e. Boot stage, anthesis stage and boot+ anthesis stage. The experiment conducted in the department of Plant Breeding & Genetics, Ludhiana during *kharif* 2019 was laid out in Factorial Randomized Complete Block Design, whereas, other two experiments were laid out in Randomized Complete Block Design. The treatments were replicated thrice.

Rice crop was transplanted during last week of June keeping row to row and plant to plant spacing of 20 cm and 15 cm, respectively (33 hills/m^2). Recommended dose of fertilizer (N @ 105 kg ha^{-1} and Zinc sulphate @ 25 kg ha^{-1}) was applied to the crop. Nitrogen was applied through urea in three equal splits; as basal, at 21 DAT and at 42 DAT. Zinc sulphate was applied as basal. Crop was irrigated as per the crop demand. A spray of Chlorpyriphos 20 EC @ 2.5 lt ha^{-1} was done at 65 Days after transplanting to control insects.

Plant height from five randomly tagged plants in each unit was measured in centimetres from the ground level to the tip of panicle excluding awns. Ten panicles were randomly selected from each experimental plot for recording panicle weight, grain weight per panicle, number of filled and unfilled grains. Out of the bulk samples 1000 grains were counted manually and weighed on electronic balance to obtain 1000 seed weight. For recording grain yield, the grains obtained after threshing net plot (8.0 square meter) were sun dried, winnowed, cleaned and weighed on an electronic balance. For valid comparison of different treatments, moisture in grains was estimated using moisture meter. Grain yield was adjusted at 14 per cent moisture and expressed as quintals ha^{-1}.Gross returns were worked out by multiplying the paddy price (Rs. 1835/- per qt) with grain yield. For calculating net return, the cost of cultivation was subtracted from gross returns. The cost of cultivation under control was kept as Rs. 47005/- per ha (as suggested by Department of Economics and Sociology, PAU, Ludhiana) and price of potassium nitrate was Rs. 150/-per kg along with labour cost for spray Rs. 350/- per ha were added. Spray was done by using knap sack sprayer using 500 l/ha water. In addition, the occurrence of emerging rice diseases *viz*. false smut, brown leaf spot and glumes discoloration were also recorded. For assessment of these diseases, five sampling units of 1 sqm area were fixed in each plot at random. The disease score 0-9 was recorded on fifteen plants per sampling unit by counting the number of infected tillers/leaves using standard evaluation system (SES) for rice (IRRI, 2013). Data were subjected to statistical analysis using SAS 9.3 software package.

RESULTS AND DISCUSSION

Results presented in Table 1 indicated that plant height, yield attributes (panicle weight, number of filled grains per panicle, spikelet fertility, 1000 grain weight) and yield did not vary significantly in response to potassium nitrate spray but there was consistent numerical increment in yield attributes; and ultimately grain yield of both the genotypes (PR 126 and PR 124) increased over control (unsprayed) by a margin of 1.4 to 1.8 q ha^{-1} and 1.9 to 3.0 q ha^{-1}, respectively. Although 1000 grain weight of paddy is reported to be a stable character and under strong genetic control (Dingkuhn *et al.,* 2017), but even then it had improved marginally in response to foliar application of potassium nitrate. Increase in yield attributes of rice due to foliar spray of KNO_3 at critical stages could be ascribed to the overall improvement in plant growth, vigour and production of photosynthates owing to increased availability, absorption and translocation of nutrients in plant (Ravi

Table 1. Effect of foliar application of potassium nitrate (13:0:45) on growth and grain yield of rice varieties during *kharif* 2018

Treatment*	Plant height (cm)		Panicle weight (g)		Filled grains per panicle		Fertility (per cent)		1000 grain weight (g)		Grain yield (t/ha)	
	PR 126	PR 124	PR 126	PR 124	PR 126	PR 124	PR 126	PR 124	PR 126	PR 124	PR 126	PR 124
Control (unsprayed)	103.5	107.8	3.23	3.05	153.3	126.5	83.9	91.1	21.11	23.99	7.81	7.42
Water spray	101.6	105.9	3.25	3.04	153.1	126.9	84.1	91.6	21.15	23.98	7.82	7.44
Potassium nitrate 1.0%	104.1	107.3	3.28	3.08	155.5	128.9	85.0	92.6	21.15	24.06	8.00	7.56
Potassium nitrate 1.5%	103.5	106.0	3.33	3.10	157.9	129.0	86.6	93.3	21.12	24.05	8.09	7.61
Potassium nitrate 2.0%	103.9	106.6	3.34	3.09	159.2	129.0	87.4	93.0	21.15	24.09	8.11	7.60
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*applied at boot stage

et al., 2007). It was hypothesised that comparatively lesser yield gain of PR 124 than that of PR 126 due to potassium nitrate application may be ascribed to better inherent spikelet fertility of PR 124 owing to lesser number of grains per panicle. To test this hypothesis, another experiment was conducted with genotypes (PR 128 and PR 129) having more grain numbers per panicle.

Data revealed that stage of application of potassium nitrate showed no significant difference with respect to yield, yield attributes (Table 2) and disease severity (Data not presented), but application at boot stage has given highest net returns (Rs. 96978 and 94133 per ha in case of PR 128 and PR 129, respectively). Amongst potassium nitrate concentrations, there was significant improvement in grain yield of PR 128 (4.1 q ha^{-1}) and PR 129 (3.2 qha^{-1}) with1.5 and 2.0 per cent over control (water spray). This may be due to significant improvement in spikelet fertility (2.4 to 2.7 per cent) and numerical improvement in other yield attributes such as panicle weight (2.6 to 3.4per cent), number of filled grains per panicle (2.6 to 3.1per cent). None of the interaction effects were significant. Although gross returns were marginally higher under treatment of 2.0 per cent potassium nitrate spray but owing to very meagre differences in grain yield under 1.5 and 2.0 per cent potassium nitrate, foliar application of 1.5 per cent potassium nitrate on PR 128 and PR 129 resulted in the highest net returns (Rs. 98314 and 93765 per ha), which were Rs. 5301 and 3735 per ha higher than control (Table 2). Khan *et al.* (2012) also reported higher economic returns in rice using 2.0% and 1.5% foliar application of KNO_3. It was also observed that potassium nitrate spay did not cause

Table 2. Effect of different concentrations and stage of foliar application of potassium nitrate on yield attributes, yield and economics of rice varieties during *kharif* 2019

Treatment	Panicle weight (g)		Filled grains per panicle		Fertility (per cent)		Grain Yield (t ha^{-1})		Gross returns (Rs. ha^{-1})		Net returns (Rs. ha^{-1})		Additional income over control (Rs. ha^{-1})	
	PR 128	PR 129	PR 128	PR 129	PR 128	PR 129	PR 128	PR 129	PR 128	PR 129	PR 128	PR 129	PR 128	PR 129
Stage of foliar spray														
Boot	4.19	4.34	141.9	144.4	79.2	78.2	7.90	7.75	145047	142202	96978	94133	5842	5100
Anthesis	4.11	4.31	139.7	140.4	79.1	77.3	7.73	7.52	141766	137989	93233	89456	-261	-26
Boot + anthesis	4.17	4.33	142.7	144.6	79.2	78.9	7.93	7.71	145509	141422	96080	91993	4090	2247
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	-	-	-	-	-	-
Potassium nitrate concentration														
Control (water spray)	4.07	4.24	139.6	139.9	77.9	76.5	7.63	7.47	140018	137036	93013	90031	-	-
1.0%	4.14	4.30	139.5	143.4	78.9	77.9	7.70	7.57	141300	138839	92653	90192	-359	161
1.5%	4.21	4.35	143.2	144.3	79.8	78.6	8.04	7.79	147548	143000	98314	93765	5301	3735
2.0%	4.21	4.41	143.4	144.8	80.1	79.5	8.04	7.81	147563	143277	97742	93455	4729	3425
LSD (p=0.05)	NS	NS	NS	NS	NS	1.0	0.33	0.31	-	-	-	-	-	-

Table 3. Effect of foliar application of potassium nitrate on yield, yield attributes and economics of paddy (*var*. PR 121) during *kharif* 2019

Treatment		Panicle weight (g)	Filled grains per panicle	Fertility (per cent)	1000 Seed weight (g)	Grain yield (tha^{-1})	Gross returns ($Rs.ha^{-1}$)	Net returns (Rs. ha^{-1})	Additional income over control (Rs. ha^{-1})
Control (water spray)		2.73	112	85.5	25.97	7.71	141479	94474	-
Potassium nitrate @ 1.5%		2.93	121	89.7	26.50	8.08	148268	100813	6339
Potassium nitrate @ 2.0%	Boot stage	3.00	120	88.9	26.54	8.09	148452	100847	6373
Potassium nitrate @ 2.5%		2.80	114	83.6	25.96	7.82	143497	95742	1268
Potassium nitrate @ 1.5%		2.73	110	86.1	26.39	7.83	143681	96226	1752
Potassium nitrate @ 2.0%	Anthesis stage	2.80	110	85.1	26.41	7.80	143130	95525	1051
Potassium nitrate @ 2.5%		2.65	108	86.8	26.37	7.61	139644	91889	-2586
Potassium nitrate @ 1.5%		2.79	118	87.2	26.43	8.01	146984	99079	4605
Potassium nitrate @ 2.0%	Boot + Anthesis stage	2.83	115	86.3	25.75	7.95	145883	97678	3204
Potassium nitrate @ 2.5%		2.63	112	86.1	25.20	7.61	139644	91139	-3336
LSD (p=0.05)		NS	7.2	3.2	NS	0.07	-	-	-

significant effect on severity of rice diseases *viz*; glume discoloration, false smut and brown leaf spot (Data not presented). Among different treatments, severity of grain discoloration, false smut and brown leaf spot ranged between 0-0.8, 0-0.6 and 3.0-4.7 per cent, respectively. Ou (1985) reported increased incidence of brown leaf spot under potassium, manganese and silica deficiency. However, the incidence of false smut is reported to increase with increase in nitrogen dose due to increased crop succulence. (Rani *et al.,* 2015). Low false smut incidence under different treatments under our conditions can be ascribed to the fact that nitrogen concentration was low and was just sufficient to meet the crop demand without causing excessive succulence.

Findings presented in Table 3 also showed significant improvement in spikelet fertility (4.3 per cent) and number of filled grains per panicle (7.3); consequently numerical gain in grain yield (3.7 qha^{-1}) with foliar spray of potassium nitrate at boot stage. Data also showed that application of potassium nitrate at two stages i.e. boots+ anthesis stage failed to enhance grain yield over single application at boot stage. Further, it was found that role of potassium nitrate spray mainly lied in enhancing the spikelet fertility and grain weight. Bhuyan *et al.* (2012) and Mahajan and Khurana (2014) reported that foliar application of nitrogen and potassium decreases the panicle sterility and ultimately increases grain yield of rice.

The higher grain yield under potassium nitrate spray treatments may be attributed to the beneficial effects of NO_3^- in delaying synthesis of abscisic acid and increased cytokinin activity that causes higher chlorophyll retention and thereby higher photosynthesis activity in leaves for supply of photosynthate to grains. Besides this beneficial role of potassium on photosynthesis, carbohydrate redistribution and starch synthesis in storage organs might have played significant role (Imas and Magen, 2007).

It can be concluded that for improving spikelet fertility, grain weight, grain yield and ultimately for higher net returns from paddy, potassium nitrate @ 1.5 per cent should be sprayed at boot stage using 500 lt water per ha.

Authors' contribution

Conceptualization of research work and designing of experiments (BSD, GK, TPS); Execution of field/ lab experiments and data collection (GK, BSD, TPS, JSL); Analysis of data and interpretation (BSD, GK); Preparation of manuscript (BSD, GK, TPS)

LITERATURE CITED

Bhuyan M H M, Ferdousi M R, and Iqbal M T 2012. Foliar spraying of nitrogen fertilizer increases the yield of rice over conventional method. *ISRN Agron***1 0**: 12-20.

Dingkuhn M, Pasco R, Pasuquin JM, Damo J, Soulié J C, Raboin L M, Dusserre J , Sow A, Manneh B, Shrestha S and Kretzschmar T 2017. Crop-model assisted phenomics and genome-wide association study for climate adaptation of indica rice. 2. Thermal stress and spikelet sterility. *J Exp Bot* **68**: 4389-4406.

FAO 2017.*The future of food and agriculture – Trends and challenges*. Rome.

FAO 2018.*Rice market monitor*. FAO Rome **21**: 4.

Huang S, Chunfang Z, Yali Z and Cailin W 2017.Nitrogen Use Efficiency in Rice. In. *Nitrogen in Agriculture – Updates.* http://www.intechopen.com/books/nitrogen-in-agriculture-updates

Imas P and Magen H 2007.Management of potassium nutrition in balanced fertilization for soybean yield and quality – Global perspective. In: *Proceedings of Regional Seminar on Recent Advances in Soybean-based cropping system*. National Research Centre for Soybean, Indore. pp 1-20.

IRRI 2013. *Standard Evaluation System (SES) for rice (5th Edition). International Rice Research Institute, Manila, Philippines.pp 20-26.*

Jahan M S, Sultana S and Ali M Y 2014.Effect of different nitrogen levels on the yield performance of aromatic rice varieties. *Bull Inst Trop Agric Kyushu Univ* **37**: 47-56.

Khajuria A 2016. Impact of nitrate consumption: case study of Punjab, India. *J water resources &protec***8:** 2011-16.

Khan A W, Mann R A, Saleem M and Majeed A 2012. Comparative rice yield and economic advantage of foliar KNO_3 over soil applied K_2SO_4. *Pak J AgriSci* **49:** 481-84.

Mahajan G and Khurana M P S 2014.Enhancing productivity of dry-seeded rice (Oryzasativa L.) in north-west India through foliar application of iron and potassium nitrate. *Soc Plant Res* **27**: 301-06.

Maruyama A, Weerakoon W M W, Wakiyama Y and Ohba K 2013. Effects of increasing temperatures on spikelet fertility in different rice cultivars based on temperature gradient chamber experiments. Journal of Agronomy and Crop Science, 199, 416-423.Patra PS, Haque S (2011) Effect of seedling age on tillering pattern and yield of rice (*Oryzasativa* L.) under system of rice intensification. *ARPN J Agric & Biol Sci* **6**:33-35.

Ou S H 1985. *Rice Diseases*, 2nd edn. Kew Surrey, England, Commonwealth Mycological Institute, pp. 370

Prabhjyot-Kaur**,** Sandhu, S S, Singh H, Kaur N, Singh S and Kaur A 2016. Climatic features and their variability in Punjab. AICRPAM, School of Climate Change and Agricultural Meteorology, PAU, Ludhiana. 78 p.

Rani R, Sharma V K, Pannu P P S and Lore J S2015. Influence of nitrogen fertilizer dose on false smut of rice (*Oryzasativa*) caused by *Ustiloginoideavirens*. *Indian J AgriSci* **85**: 1003-06.

Ravi S, Ramesh S, Chandrasekharan 2007. Influence of foliar application of phytohormones and nutrients on yield and nutrient uptake of transplanted rice in Annamalainagar (TN), India. *Int J Plant Sci* **2**: 69-71.

Singh V K, Dwivedi B S, Shukla A K, Chauhan Y S and Yadav R L 2005. Diversification of rice with pigeon pea in a rice-wheat cropping system on a Typic Ustochrept: Effect on soil fertility, yield and nutrient use efficiency. *Field Crops Res* **92**: 85–105.

Singh B, Singh Y, Imas P and Xie J C 2003.Potassium nutrition of the rice-wheat cropping system. *Adv Agron* **81**: 203–59.

Wang M Q, Zheng Q and ShenGuo S 2013. The critical role of potassium in plant stress response. *Int J MolSci***14**: 7370-90.

White P J, Martin R, Broadley, Gregory P J 2012. Managing the Nutrition of Plants and People. *Appl Environ Soil Sci* **Special Issue**: 1155-67.