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Effect of potassium fertilization on growth indices, yield attributes and economics of dry direct seeded basmati rice (*Oryza sativa* L.)

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ABSTRACT

Two-year field experiment was conducted during rainy (kharif) seasons of 2015 and 2016 at ICAR-Indian Agricultural Research Institute, New Delhi to evaluate the effect of potassium (K) fertilization on growth indices, yield attributes and economicsof the dry direct seeded basmati rice. Application of recommended dose of K (60 kg ha^{-1}) half at basal and remaining half at panicle initiation increased the grain yield (5.4 tha^{-1}), net returns (Rs. 85,000 ha^{-1}) and B: C (1.8) ratio by 10, 16 and 20% respectively, over applying the entire amount of K as basal. Significant positive correlation was observed between yield attributes [total tillers(r^2=0.74), effective tillers m^{-2}(r^2=0.79)]and grain yield of dry direct seeded basmati rice. The two foliar sprays (1st spray at active tillering, 2nd spray at panicle initiation) of 2.5% potassium nitrate (T_6) increased fertile tillers % (93.8%), fertility % (83.5%) and grain yield (4.3 t ha^{-1}) by 5%, 6% and 8% respectively, over T_1 (control). In case, K is not available for top dressing then two foliar sprays of 2.5% KNO_3 at active tillering and panicle initiation stage is found optimum to obtaining higher net returns (Rs. 85200 ha^{-1}) and return from investment on K (Rs. 19.9 rupee^{-1}). Insufficient supply of K during active tillering and panicle initiation stage, decreased the production of tillers m^{-2} and conversion of tillers into fertile tillers respectively. Hence, active tillering and panicle initiation stage are most critical for K supply in dry direct seeded basmati rice.

Key words: *Dry direct seeded rice, growth indices, yield attributes, economics*

INTRODUCTION

The demand for basmati rice is increasing both in domestic and global market. Whereas the area and production of basmati rice is not stable. The basmati rice acreage has declined in key growing states like Punjab and Haryana due to crop shift which inturn reduced the basmati rice output (Anonymous, 2018). In recent years the productivity of basmati rice is decreasing due to increased incidence of various biotic and abiotic stress (Busari et al., 2015). Nutrient deficiency (Zn, S, K) is the one of the major abiotic stress which causes significant yield loss in basmati rice (Srinivasarao et al., 2011). Rice has shallow and fibrous root system. The continuous adoption of rice-wheat cropping system (RWCS) and imbalance fertilization in Indo-Gangetic Plains caused mining of native soil potassium reserve (Singh et al., 2003). As a result, the RWCS of IGP has started responding to the external K fertilization. But the prevailing light textured soil (sandy loam) causes leaching of significant amount of externally applied inorganic nutrients like nitrogen and potassium (Islam et al., 2014).

Declining ground water table and contamination of ground water due to injudicious use of fertilizer threaten the sustainability of the RWCS (Humphreys et al., 2010). The development and adoption of water saving technologies for rice is essential to overcome these problems. Direct seeded rice (DSR) has the potential to save up to 50% irrigation water requirement of rice (Kumar et al., 2017). However, DSR is more prone to K deficiency since it does not receive sufficient irrigation water, which can otherwise add certain amount of K to the soil (Singh and Wanjari, 2012). In addition, availability of K is reduced in DSR (aerobic soil) in comparison to conventional system (submerged soil). So, it is necessary to develop appropriate nutrient management practices for dry direct seeded rice grown in IGPs. Application of K based on 4R nutrient stewardship (right time, right dose, right method, right place) may enhance the yield and economics of dry direct seeded rice by minimizing the nutrients losses and moisture stress. Keeping this in view, we conducted a two-year field experiment to study the effect of rate, method, time and source of K fertilization on growth, yield attributes and economicsofdirect seeded ricegrown in IGPs.

MATERIALS AND METHODS

A two-year field experiment was conducted during *kharif* season of 2015 and 2016 at research farm of ICAR-Indian Agricultural Research Institute (IARI), New Delhi, situated at a latitude of 28°40'N and longitude of 77°12'E, and at an altitude of 228.6 m above the mean sea level. The climate of site is semi-arid type with hot and dry summer and cold winter with mean annual normal rainfall of 650 mm, of which 80% is received through south-west monsoon (July-September). The soil of experimental plot (before starting of experiment) was sandy clay loam in texture with 7.5 pH, EC (0.32 dS m^{-1}), OC (0.55%), available N-201 kg ha^{-1} (Subbiah and Asija, 1956), available P-12.8 kg ha^{-1} (Olsen et al., 1954) and available K-213.8 kg ha^{-1} (1 N NH_4OAc-extractable K) (Hanway and Heidel, 1952).

The experiment was conducted in randomized block design with 12 treatments, and three replications. The treatment details are presented in Table 1. During both the years of experiment, rice was sown and harvested during second fortnight of June and October respectively, with the row spacing of 0.25 m and seed rate 40 kg ha^{-1}. Rice cultivar 'Pusa Basmati 1509' was sown using seed drill. The recommended dose of N (120 kg ha^{-1}) was applied in 3 splits by applying 1/3rd at 10 DAS, 1/3rd at tillering (40 DAS) and remaining 1/3rd at panicle initiation stage (70 DAS). The entire dose of phosphorus (60 kg ha^{-1}) was applied as basal just before sowing the crop. Subsequently, it was incorporated into the soil by seed drill while sowing. The nitrogen and phosphorus was applied through urea and single super phosphate (SSP) by broadcasting during both the years of experiment. Potassium was applied according to the desired treatments. The first foliar spray of 2.5% potassium nitrate (KNO_3)was given at active tillering (40 DAS) and second spray was given at panicle initiation stage (70-75 DAS) only in selected treatments. Remaining all other cultural practices were carried out according to standard recommendations.Crop was harvested manually and the grain yield of rice was measured at 14% moisture content and expressed in t ha^{-1}.

For computing growth indices, the dry matter production from each treatment was recorded at 30 days interval. The recorded dry weight data at 30 days intervalwas used to calculate the mean crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR).The mean CGR, RGR and NAR was worked out with the following formulae (Watson et al., 1952) and expressed as g m^{-2} land area day^{-1}, mg g dry $matter^{-1} day^{-1}$ and g m^{-2} leaf area day^{-1} respectively. The number of tillers m^{-2} was calculated by counting total number of tillers in 0.5 m x 0.5 m quadrate at the time of grain filling and as total number m^{-2}.

$$\text{Mean CGR} = \left(\frac{W_1 - W_2}{T_2 - T_1}\right)\left(\frac{1}{S}\right)$$

$$\text{Mean RGR} = \frac{\text{Ln}W_2 - \text{Ln}W_1}{T_2 - T_1}$$

$$\text{Mean NAR} = \left(\frac{W_2 - W_1}{LA_2 - LA_1}\right)\left(\frac{\text{Ln}LA_2 - \text{Ln}LA_1}{T_2 - T_1}\right)$$

Where, W_1 and W_2 are the dry weight of plants in g at the time of T_1 and T_2 respectively; LA_1 and LA_2 are the leaf area in m^2 at the time of T_1 and T_2 respectively; T_1 and T_2 are the time interval in days; S is the land area occupied by plants in m^2. Ln is the natural logarithm.

The cost of cultivation (COC) was calculated using the current market price of the inputs used. Similarly, gross return (GR) was calculated based on the grain and straw yield of rice for each season based

Table 1. Treatments details

Trt. no.	Treatment symbol	Treatment details	K_2O (Kg ha^{-1})
T_1	No K	No potassium application in both the year	0
T_2	100% B	Entire recommended dose of potassium (RDK) was applied at the time of sowing in both the year through muriate of potash (MOP)	60
T_3	50% B	50% of the RDK was applied at the time of sowing in both the year through MOP	30
T_4	50% B+50% PI	50% of the RDK was applied at the time of sowing, remaining 50% applied at panicle initiation (PI) stage in both the year through MOP	60
T_5	75% B+25% PI	75% of the RDK was applied at the time of sowing, remaining 25% applied at PI stage in both the year through MOP	60
T_6	2 FS	Two foliar spray (FS) of 2.5% KNO_3 [1st FS @ active tillering (AT), 2nd FS @ PI]	8.8
T_7	100% B+2 FS	Basal application of 100% RDK at the time of sowing + 2 FS of 2.5 % KNO_3[1st FS @ AT, 2nd FS @ PI]	68.8
T_8	50% B+2 FS	Basal application of 50% RDK at the time of sowing + 2 FS of 2.5 % KNO_3[1st FS @ AT, 2nd FS @ PI]	38.8
T_9	75% B+2 FS	Basal application of 75% RDK at the time of sowing + 2 FS of 2.5 % KNO_3[1st FS @ AT, 2nd FS @ PI]	53.8
T_{10}	50% B+25% PI+ 2 FS	Basal application of 50% RDK at the time of sowing + 50% RDK at PI + 2 FS of 2.5 % KNO_3[1st FS @ AT, 2nd FS @ PI]	68.8
T_{11}	75% B+25% PI+ 2 FS	Basal application of 75% RDK at the time of sowing + 25% RDK at PI +2 FS of 2.5 % KNO_3 [1st FS @ AT, 2nd FS @ PI]	68.8
T_{12}	150% B	150% RDK was applied at the time of sowing in both the year	90

on their prevailing market price. During the study period, the market price of basmati rice and straw was Rs. 22 kg^{-1}and Rs. 1.8 kg^{-1} respectively. The GR, NR, B: C ratio and return on investment (ROI) on K was calculated using standard formula.

Gross retun (Rs./ha) = [Grain yield (kg/ha) × Cost of one kg grain] + [Straw yield (kg/ha) × Cost of one kg straw]

Net return (Rs./ha) = Gross return (Rs./ha) - Cost of cultivation (Rs./ha)

B:C ratio = (Net return (Rs./ha)) / (Cost of cultivation (Rs./ha))

ROI on K fertilizer = (Yield increase due to K fertilizer (kg/ha) x MSP of crop (Rs./kg) / (Applied K_2O (kg/ha) x Cost of K_2O (Rs./kg))

Statistical analysis

All the data were subjected to one-way analysis of variance (ANOVA) using the general linear model procedures of the Statistical Analysis System (SAS Institute, Cary, NC). The F-test was used to determine significant effects of potassium fertilizer and least significant difference (LSD) was used to compare means.

RESULTS AND DISCUSSION

Growth indices

Data pertaining to CGR, RGR and NAR of dry direct seeded basmati rice is given in Table 2. The CGR was found non-significant up to 30 DAS. On pooled average basis, during 31-60 DAS the highest CGR was recorded in T_{12} (150% B) which remained at par with T_2 (100% B) and T_7 (100% B + 2 FS). Whereas, at 61-90 DAS treatment T_7 (100% B + 2 FS) recorded the highest CGR which remained at par with T_4 (50% B + 50% PI), T_5 (75% B + 25% PI), T_9 (75% B + 2 FS), T_{10} (50% B + 50% PI + 2 FS) and T_{11} (75% B + 25% PI + 2 FS). At 91 DAS-harvest the highest CGR was recorded in T_{10} (50% B + 50% PI + 2 FS) which remained at par with T_{11} (75% B + 25% PI + 2 FS). The RGR was found non-significant upto 60 DAS. During 61-90 DAS the highest RGR was recorded in T_{11} (75% B + 25% PI + 2 FS) which remained at par with T_4 (50% B + 50% PI), T_5 (75% B + 25% PI), T_7 (100% B + 2 FS), T_9 (75% B + 2 FS) and T_{10} (50% B + 50% PI + 2 FS). Whereas, at 91 DAS-harvest the highest RGR was recorded in T_{10} (50% B + 50% PI +

2 FS) which remained at par with T_4 (50% B + 50% PI), T_7 (100% B + 2 FS), T_9 (75% B + 2 FS) and T_{11} (75% B + 25% PI + 2 FS). Similar to RGR, the NAR was found non-significant upto 60 DAS. During 61-90 DAS the highest NAR was recorded in T_4 (50% B + 50% PI) which remained at par with T_6 (2 FS), T_7 (100% B + 2 FS), T_{10} (50% B + 50% PI + 2 FS) and T_{11} (75% B + 25% PI + 2 FS). Whereas, at 91 DAS-harvest the highest NAR was recorded in T_7 (100% B + 2 FS) which remained at par with T_4 (50% B + 50% PI), T_5 (75% B + 25% B + 2 FS), T_9 (75% B + 2 FS), T_{10} (50% B + 50% PI + 2 FS) and T_{11} (75% B + 25% PI + 2 FS). At all the stages of crop growth T_1 (no K) recorded the lowest CGR, RGR and NAR. Under treatments T_2 and T_{12} the CGR, RGR and NAR were higher upto 30 DAS after that it started decreasing. It shows insufficient supply of K in later stage of the crop reduced plant growth which inturn reduced the CGR, RGR and NAR. Whereas, the higher CGR, RGR and NAR in treatment T_4, T_5, T_7, T_9, T_{10}, T_{11} during 61 DAS to harvest shows, supply of K during active tillering and panicle initiation stages either through foliar sprays or split application increased the plant growth and dry matter production. Thus increased plant growth and dry matter production inturn increased the CGR, RGR and NAR. Meena et al., (2003) andMuthukumararajaet al. (2009) reported that CGR, RGR and NAR is increased by application of potassium.

Yield attributes and yield

It is evident from the data that application of K significantly increased total number of tillers m^{-2} and fertile tillers m^{-2} (Table 2). On pooled average basis, the highest number of total tillers m^{-2} and fertile tillers m^{-2} was recorded in treatments T_{10} (50% B + 50% PI + 2 FS) which remained at par with T_4 (50% B + 50% PI), T_5 (75% B + 25% PI), T_7 (100% B + 2 FS), T_9 (75% B + 2 FS), T_{11} (75% B + 25% PI + 2 FS) and T_{12} (150% B). The lowest number of total tillers m^{-2} and fertile tillers m^{-2} was recorded under T_1 (control).It was observed that more number of fertile tillers was recorded in treatments where the recommended dose of K was applied in split doses or K is supplemented at later stages (tillering, panicle initiation) through foliar spray. The split application of RDK increased fertile tillers percentage by 32-34% over control (no K). The fertile tillers m^{-2} was found in the order of $T_4 = T_5 = T_7 = T_9 =$

Table 2. Effect of K application on growth indices and yield attributes of dry direct seeded basmati rice (two year pooled data).

Treat-ments	Crop growth rate (g m^{-2} land area day^{-1})				Relative growth rate (mg g^{-1} dry matter day^{-1})			Net assimilation rate (mg m^{-2} leaf area day^{-1})			Total tillers m^{-2}(Nos)	Fertile tillers m^{-2} (Nos)
	0-30 DAS	31-60 DAS	61-90 DAS	91-Harvest	31-60 DAS	61-90 DAS	91-Harvest	31-60 DAS	61-90 DAS	91-Harvest		
T_1	2.19	9.08^{F}	19.29^{D}	5.13^{DEF}	54.85	33.18^{F}	2.32^{E}	2.63	4.36^{DE}	5.08^{E}	313^{D}	280^{C}
T_2	2.27	10.98^{AB}	24.31^{BC}	4.98^{EF}	59.04	34.71^{DEF}	4.17^{CD}	2.45	4.38^{DE}	5.40^{DE}	354^{B}	339^{B}
T_3	2.23	9.83^{DE}	23.63^{BC}	2.58^{I}	56.48	36.16^{CD}	3.76^{D}	2.45	4.63^{BCDE}	5.54^{CD}	326^{CD}	308^{C}
T_4	2.22	10.39^{BCD}	28.46^{A}	6.06^{BC}	58.11	39.35^{A}	4.61^{ABC}	2.48	4.99^{A}	5.92^{ABC}	380^{A}	371^{A}
T_5	2.25	10.54^{BC}	28.25^{A}	5.92^{CD}	58.07	38.86^{AB}	4.51^{BCD}	2.47	4.41^{CDE}	5.95^{AB}	376^{AB}	367^{A}
T_6	2.19	9.56^{EF}	22.26^{C}	3.06^{HI}	56.24	35.41^{CDE}	2.89^{E}	2.54	4.73^{ABC}	5.42^{DE}	324^{D}	304^{C}
T_7	2.28	11.30^{A}	29.32^{A}	5.11^{DEF}	59.64	38.33^{AB}	5.23^{AB}	2.48	4.77^{AB}	6.02^{A}	383^{A}	373^{A}
T_8	2.25	10.12^{CDE}	25.28^{B}	4.49^{FG}	57.05	37.11^{BC}	3.78^{D}	2.57	4.52^{BCDE}	5.55^{BCD}	351^{BC}	338^{B}
T_9	2.27	10.46^{BCD}	28.88^{A}	3.87^{GH}	57.65	39.46^{A}	4.64^{ABC}	2.53	4.41^{CDE}	5.99^{A}	369^{AB}	360^{AB}
T_{10}	2.24	10.52^{BC}	28.94^{A}	7.25^{A}	58.14	39.47^{A}	5.36^{A}	2.52	4.69^{ABCD}	5.90^{ABC}	391^{A}	383^{A}
T_{11}	2.25	10.45^{BCD}	29.03^{A}	6.86^{AB}	57.80	39.65^{A}	5.08^{AB}	2.48	4.81^{AB}	5.89^{ABC}	389^{A}	381^{A}
T_{12}	2.26	11.33^{A}	23.73^{BC}	5.55$_{CDE}$	60.00	33.67^{EF}	2.99^{E}	2.40	4.33^{E}	5.23^{DE}	372$_{AB}$	360^{AB}
SE(d)	0.216	0.326	1.315	0.405	3.102	1.022	0.370	0.245	0.166	0.199	12.42	12.36
LSD at 5%	NS	0.677	2.726	0.840	NS	2.120	0.767	NS	0.344	0.413	25.75	25.63

Means followed by a superscripted similar letter within a column are not significantly different (at $P < 0.05$) according to LSD test.

$T_{10} = T_{11} = T_{12} > T_2 = T_8 = T_3 = T_6 > T_1$. Similar results of increased fertile tillers m^{-2} and fertility percentage of rice by foliar sprays and top dressing of K was also reported by Maurya et al. (2015) and Lv et al. (2017). With respect to grain yield, the treatment T_{11} (75% B + 25% PI + 2 FS) recorded the highest grain yield which remained at par with T_4 (50% B + 50% PI), T_5 (75% B + 25% PI), T_7 (100% B + 2 FS), T9 (75% B + 2 FS) and T_{10} (50% B + 50% PI + 2 FS). The grain yield ranged from 3.98 to 5.45 t ha^{-1}. Treatments *viz*., T_4, T_5, T_7, T_9, T_{10}, T_{11} increased the grain yield by 10 and 21% over T_2 (100% B) and T_3 (50% B) respectively. It shows insufficient supply of K reduces grain yield of dry direct seeded basmati rice. The yield difference between T_1 (control) and T_6 (2 FS) is statistically significant, and T_6 (2 FS) increased grain yield by 8% over T_1 (control). However, basmati rice yield was not increased if foliar spray is combined with split application of RDK. The study of correlation between yield attributes [total tillers m^{-2} ($r^2 = 0.74$), fertile tillers m^{-2} ($r^2 = 0.79$)] and yield showed a strong positive and significant correlation Fig. 1 (a & b).

Economics

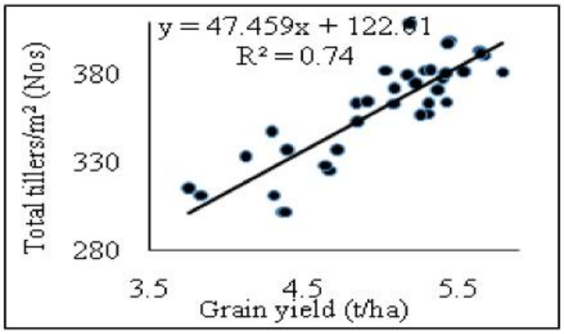
Data pertaining to production cost, gross return, net return, B: C ratio and return from investment on K fertilizers are presented in Table 3. The production cost of basmati rice was increased with increasing rate ofK application. Among the treatments, the highest production cost of Rs. 48.6 x 103 ha^{-1} was recorded in T_{12} (150% B) whereas the lowest (Rs. 45.9 x103 ha^{-1}) was recorded in T_1 (control). The gross return, net return and B: C ratio of basmati rice was found in the range of Rs. 99.5 to 133.8 $x10^3$ ha^{-1}, Rs. 53.6 to 85.5 $x10^3$ ha^{-1} and 1.2 to 1.8, respectively. Among the treatments the highest gross return, net return and B: C ratio was recorded in T_{11} (75% B + 25% PI + 2 FS) which remained at par with T_4 (50% B + 50% PI), T_5 (75% B + 25% PI), T_7 (100% B + 2 FS), T_9 (75% B + 2 FS), T_{10} (50% B + 50% PI + 2 FS).

Thus, application of K to dry direct seeded basmati rice is highly economical. On pooled average basis, treatment T_4 (50% B + 50% PI) gave 20% higher B: C ratio over T_2 (100% B). It shows that for direct seeded basmati rice, application of K in two splits in the ratio of 50:50 or 75:25 during sowing and panicle initiation stages respectively was found to give more yield and economic returns. The comparison between T_1 (control) and T_6 (2 FS) shows that in the absence of soil application of K, the foliar spray of 2.5% KNO_3 increased the net returns and B: C ratio of basmati rice significantly. However, foliar spray of 2.5% KNO_3 did not show any economic benefits if it is combined with split application of RDK. In case K is not available for top dressing then two foliar sprays of 2.5% KNO_3 at active tillering and panicle initiation stage is found economical for obtaining higher net returns. The highest

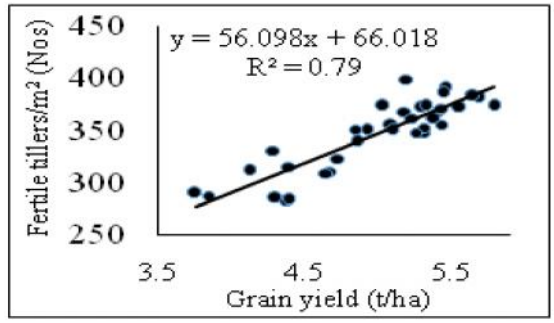
Table 3. Effect of K application on economics of dry direct seeded basmati rice (two year pooled data).

Treatments	Grain yield (tha^{-1})	Cost of cultivation ($x10^3$ Rs. ha^{-1})	Gross return ($x10^3$ Rs. ha^{-1})	Net return ($x10^3$ Rs. ha^{-1})	B: C ratio	ROI in K (Rs. Rs^{-1})
T_1	3.98^{D}	45.9	99.5^{E}	53.6^{D}	1.2^{E}	-
T_2	4.90^{B}	47.7	121.1^{C}	73.4^{B}	1.5^{C}	11.0^{D}
T_3	4.45^{C}	46.8	110.2^{D}	63.4^{C}	1.4^{D}	11.6^{D}
T_4	5.42^{A}	47.7	133.1^{AB}	85.4^{A}	1.8^{A}	17.9^{BC}
T_5	5.40^{A}	47.7	132.6^{AB}	84.9^{A}	1.8^{A}	17.6^{BC}
T_6	4.31^{CD}	46.5	107.0^{DE}	60.5^{CD}	1.3^{DE}	28.1^{A}
T_7	5.42^{A}	48.3	133.0^{AB}	84.7^{A}	1.8^{A}	15.6^{C}
T_8	4.90^{B}	47.4	120.9^{C}	73.5^{B}	1.6^{BC}	17.6^{BC}
T_9	5.42^{A}	47.9	133.0^{AB}	85.2^{A}	1.8^{A}	19.9^{B}
T_{10}	5.44^{A}	48.3	133.5^{AB}	85.2^{A}	1.8^{A}	15.8^{C}
T_{11}	5.45^{A}	48.3	133.8^{A}	85.5^{A}	1.8^{A}	16.2^{C}
T_{12}	5.09^{AB}	48.6	125.3^{BC}	79.2^{AB}	1.7^{AB}	9.2^{D}
SE(d)	0.178	-	4.05	4.05	0.09	1.23
LSD at 5%	0.369	-	8.41	8.41	0.12	2.56

Means followed by a superscripted similar letter within a column are not significantly different (at $P < 0.05$) according to LSD test.



a) Total tillers m^{-2} and grain yield



b) Fertile tillers m^{-2} and grain yield

Fig. 1. Relationship between total tillers m^{-2} and grain yield (a), fertile tillers m^{-2} and grain yield (b)

return on investment (RIO) in K fertilizer was obtained under T_6 (2 FS) whereas T_{12} (150% B) recorded the lowest. The range of ROI in K was found between Rs. 9.2 to 28.1 rupee^{-1}. The split application of RDK increased the net return, B: C ration and return from investment on K fertilizer without increasing the production cost. This is due to higher yield increase by split application of K compared to application of entire dose as basal. The increased grain yield in turn increased net return and B: C ratio. The lowest ROI in K fertilizer in T_{12} (150% B) and T_2 (100% B) is due to higher cost of K fertilization and relatively lower yield improvement in comparison to splits or foliar application of K. Rahmatullah et al. (2007) reported that application of 60 kg K2O/ha is optimum for obtaining maximum net return and value cost ratio (3.9:1) in rice-wheat cropping system. Based on multi location trails in different part of IGPs, application of 40-60 kg K_2O ha^{-1} found to provide good ROI to the farmers and will maintain the K fertility status of the soil (Majumdar et al., 2012).

CONCLUSION

Based on two year experimental results, it is recommended that in dry direct seeded basmati ricefor better crop growth and profit, the recommended dose of K (60 kg K_2O ha^{-1}) should be applied in two equal splits (50% B + 50% PI). Application of 60 kg K_2O or a higher dose of K_2O at the time of sowing is not economical. In case K is not available for top dressing then two foliar sprays of 2.5% KNO_3 at active tillering and panicle initiation stage is found economical for obtaining higher net returns. Insufficient supply of K during active tillering and panicle initiation stage, decrease the production of tillers and conversion of fertile tillers respectively. It may be concluded that, active tillering and panicle initiation stage are most critical for K supply in dry direct seeded basmati rice.

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