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Magnesium sulphate fertilization for yield enhancement in direct seeded rice

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ABSTRACT

A field study was conducted during kharif, 2017 to find out the optimum dose, time and method of application of $MgSO_4$ for growth and yield enhancement in direct seeded rice.Results revealed that $MgSO_4$ application had significant influence on yield attributes, yield and economics of direct seeded rice. Application of $MgSO_4$ @ 40 kg ha^{-1} in two equal splits at 20 and 40 DAS (T_6) registered the highest grain yield and was statistically comparable with the application of $MgSO_4$ @ 20 kg ha^{-1} at 20 DAS along with foliar spray of 1 % $MgSO_4$ at 40 DAS (T_9), $MgSO_4$ @ 20 kg ha^{-1} in two equal splits at 20 and 40 DAS (T_4) and $MgSO_4$ @ 10 kg ha^{-1} at 20 DAS along with foliar spray of 2% $MgSO_4$ at 40 DAS (T_{10}). Split application was found to be superior and $MgSO_4$ @ 40 kg ha^{-1} in two equal splits at 20 and 40 DAS registered the highest grain yield and B:C ratio. Application of $MgSO_4$ @ 40 kg ha^{-1} in two equal splits at 20 and 40 DAS can be given as recommendation for farmers for getting higher grain yield and net income.

***Keywords*:** Direct seeded rice, economics, magnesium, yield

Rice is "life" for more than sixty per cent of the world's population and plays a major role in the economic and social stability of the world. Magnesium has vital role in number of key functions in plants, *viz*., photo phosphorylation, carbon dioxide fixation, protein synthesis, chlorophyll formation, phloem loading, partitioning and utilization of photo assimilates, generation of reactive oxygen species, and photo oxidation in leaf tissues. Ding (2006) reported that net photosynthetic rate in rice leaves decreases as the Mg content in shoot decreases. If Mg deficiency occurs, these processes are adversely affected, leading to impairment in quality, growth and yield. Despite the well-known role of Mg in crop growth and yield, research on Mg nutrition in crop production and quality is meager. Hence, Mg is often considered as a "forgotten essential nutrient element".

Study conducted by Kerala State Planning Board pointed out the widespread deficiency of Mg in Kerala, except, Attappady and Central and Eastern Palakkad regions (Kerala state Planning Board, 2013). Deficiency of Mg may be due to the imbalanced application of primary nutrients, leaching due to heavy rainfall, crop removal, acidic condition of the soil and high levels of Ca and K (Biswas*et al*., 2013). Due to its potential for leaching in highly weathered soils and interaction with Al, Mg deficiency is a growing concern in acid soils. With this background, the present investigation was undertaken to study the optimum dose, time and method of application of $MgSO_4$ for growth and yield enhancement in direct seeded rice.

Short communication

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The ûeld experiment was conducted at farmer's field in Kalliyoor Panchayat, Thiruvananthapuram, Kerala, India, situated at 8°26.762'N latitude and 77°0.136' E longitude and 29 m above mean sea level (MSL) during *Kharif* season of 2017. The experiment was laid out in randomized block design (RBD) with three replications and fourteen treatments. The variety used was Sreyas, a new variety released from Rice Research Station, Moncompu, Alappuzha, Kerala. The treatments were $MgSO_4$ @ 20 kg ha^{-1} at 20 days after sowing (DAS) (T_1), $MgSO_4$ @ 30 kg ha^{-1} at 20 DAS (T_2) , $MgSO_4$ @ 40 kg ha^{-1} at 20 DAS (T_3), $MgSO_4$ @ 20 kg ha^{-1} in two equal splits at 20 and 40 DAS (T_4), $MgSO_4$ @ 30 kg ha^{-1} in two equal splits at 20 and 40 DAS (T_5), $MgSO_4$ @ 40 kg ha^{-1} in two equal splits at 20 and 40 DAS (T_6), $MgSO_4$ @ 10 kg ha^{-1} at 20 DAS and 1% $MgSO_4$ at 40 DAS as foliar spray (T_7), $MgSO_4$ @ 15 kg ha^{-1} at 20 DAS and1% $MgSO_4$ at 40 DAS as foliar spray (T_8), $MgSO_4$ @ 20 kg ha^{-1} at 20 DAS and $MgSO_4$ 1% at 40 DAS as foliar spray (T_9), $MgSO_4$ @ 10 kg ha^{-1} at 20 DAS and 2% $MgSO_4$ at 40 DAS as foliar spray (T_{10}), $MgSO_4$ @ 15 kg ha^{-1} at 20 DAS and 2% $MgSO_4$ at 40 DAS as foliar spray (T_{11}), $MgSO_4$ @ 20 kg ha^{-1} at 20 DAS and 2% $MgSO_4$ at 40 DAS as foliar spray (T_{12}), $MgSO_4$ @ 80 kg ha^{-1} as basal (adhoc recommendation of Kerala Agricultural University (KAU)) (T_{13}), and (T_{14}) Control (Package of practices recommendations of KAU (KAU, POP) *i.e*., without Mg.

Table 1: Effect of magnesium sulphate on yield attributes of direct seeded rice

Treatments	Productive tillers (no. m^{-2})	Filled grains (no. $panicle^{-1}$)	Sterility (%)	1000 grain weight (g)
T_1: $MgSO_4$ @ 20 kg ha^{-1} at 20 DAS	534.3	122.07	15.38	27.80
T_2: $MgSO_4$ @ 30 kg ha^{-1} at 20 DAS	559.0	122.53	15.09	28.30
T_3: $MgSO_4$ @ 40 kg ha^{-1} at 20 DAS	564.7	124.73	16.04	28.17
T_4: $MgSO_4$ @ 20 kg ha^{-1} at two splits at 20 and 40 DAS	576.7	126.53	14.88	29.90
T_5: $MgSO_4$ @ 30 kg ha^{-1} at two splits at 20 and 40 DAS	548.3	125.47	16.12	29.13
T_6: $MgSO_4$ @ 40 kg ha^{-1} at two splits at 20 and 40 DAS	577.7	133.20	13.27	29.77
T_7: $MgSO_4$ @ 10 kg ha^{-1} at 20 DAS + 1% foliar spray at 40 DAS	559.0	123.40	14.79	28.90
T_8: $MgSO_4$ @ 15 kg ha^{-1} at 20 DAS + 1% foliar spray at 40 DAS	554.7	127.20	17.05	28.93
T_9: T_1 + 1% foliar spray at 40 DAS	576.7	129.73	12.77	29.43
T_{10}: $MgSO_4$ @ 10 kg ha^{-1} at 20 DAS + 2% foliar spray at 40 DAS	578.0	130.73	15.54	29.93
T_{11}: $MgSO_4$ @ 15 kg ha^{-1} at 20 DAS + 2% foliar spray at 40 DAS	543.7	119.13	15.40	29.30
T_{12}: T_1 + 2% foliar spray at 40 DAS	545.7	126.47	13.43	28.23
T_{13}: $MgSO_4$ @ 80 kg ha^{-1} as basal (adhoc recommendation)	536.0	121.00	17.31	28.27
T_{14}: Control (KAU, POP, without Mg)	530.3	118.70	15.95	27.50
SEm (±)	**11.61**	**2.44**	**1.03**	**0.47**
LSD(0.05)	**33.67**	**7.09**	**NS**	**1.37**

Table 2: Yield and economics of direct seeded rice as influenced by magnesium sulphate application

Treatments	Grain yield (kg ha^{-1})	Straw yield, (kg ha^{-1})	Harvest index	Net returns, ₹ ha^{-1})	B : C ratio
T_1	8666.7	11155.5	0.436	149573.93	2.79
T_2	8988.7	11577.7	0.437	158056.53	2.89
T_3	8431.0	11771.1	0.417	145620.20	2.74
T_4	9473.0	11555.5	0.451	168519.50	3.00
T_5	9026.3	11111.1	0.448	156722.87	2.86
T_6	9600.0	11053.3	0.463	169553.90	3.01
T_7	8866.7	11733.3	0.429	153502.13	2.79
T_8	8815.7	11535.5	0.432	151640.83	2.77
T_9	9500.0	11499.9	0.452	167178.90	2.95
T_{10}	9099.7	11211.1	0.447	157199.53	2.83
T_{11}	8695.3	12355.5	0.435	151238.27	2.76
T_{12}	7988.7	12119.9	0.398	134183.23	2.56
T_{13}	7259.7	12355.5	0.370	119672.83	2.42
T_{14}	7253.3	11793.3	0.381	120160.57	2.46
SEm (±)	**300.81**	**534**	**0.01**	**7460.52**	**0.05**
LSD (0.05)	**872.36**	**NS**	**0.04**	**21635.51**	**0.15**

The soil of the experimental site is acidic in reaction, high in organic carbon and medium in nitrogen, phosphorous and potassium. The crop was uniformly fertilized with recommended dose of farm yard manure (FYM) 5t ha^{-1} and N: P_2O_5: K_2O @ 90: 45: 45 kg ha^{-1}.The entire dose of FYM was applied at the time of last ploughing and fertilizers were applied in three splits: one third N and K and half P at 15 DAS, two third N and K and half P at 35 DAS and remaining one third N and K at 55 DAS. Magnesium sulphate was applied as per the treatments. All other agronomic practices were adopted as per Kerala Agricultural University Package of Practices Recommendations for Crops. The observations on yield attributes such as filled grains $panicle^{-1}$, 1000 grain weight and sterility percentage were recorded from 10 randomly selected hills, while panicles m^{-2} was recorded by placing the quadrate of size 0.25 × 0.25 m at two representative sites from each net plot area. The grain yield was recorded at 14 per cent moisture content and expressed in kg ha^{-1}. Straw was dried to constant weight under sun and expressed in kg ha^{-1}. Cost of cultivation was worked out based on the labour and input cost incurred towards rice cultivation in different treatments. Economics was worked out based on the minimum support price fixed for paddy grain (23 ‘kg^{-1}) (23 kg^{-1}) by Government of Kerala and straw @ ‘3 kg^{-1} 3 kg^{-1}. The data were statistically analyzed using ANOVA.

Yield attributes

Results presented in the table revealed that $MgSO_4$ fertilization had significant effect on the yield attributing characters of direct seeded rice (Table 1). Among the treatments, application of $MgSO_4$ @ 40 kg ha^{-1} in two equal splits at 20 and 40 DAS (T_6), $MgSO_4$ @ 20 kg ha^{-1} in two equal splits at 20 and 40 DAS (T_4), $MgSO_4$ @ 20 kg ha^{-1} at 20 DAS and 1% $MgSO_4$ as foliar spray at 40 DAS (T_9), and $MgSO_4$ @10 kg ha^{-1}at 20 DAS and 2% $MgSO_4$ as foliar spray at 40 DAS (T_{10}) registered significantly higher values for yield attributes compared to adhoc recommendation (T_{13}) and control (T_{14}). The number of panicles m^{-2}, filled grains $panicle^{-1}$ and test grain weight were the lowest in control (T_{14}). The treatments receiving $MgSO_4$ produced more number of panicles and filled grains might be due to the critical role of Mg in crop growth, implicated in photosynthesis processes, respiration and other biochemical and physiological activates (El- Zanaty *et al*., 2012). The increase in grain number due to the application of Mg was also reported by Srivastava *et al*. (2006). Sterility percentage was not significantly influenced by the treatments. Though the quantity of Mg supplied in treatment T_{13} was very high when compared to other treatments, yield recorded was low, this might be due to the low Mg use efficiency as the entire dose of Mg was given as basal leading to leaching loss of Mg due to the high mobility of Mg in soil.

Yield and economics

$MgSO_4$ fertilization has profound influence on the grain yield of direct seeded rice. Results also revealed the better performance of split application of $MgSO_4$ compared to single application. $MgSO_4$ @ 40 kg ha^{-1} in two equal splits at 20 and 40 DAS (T_6) registered the highest grain yield and was statistically comparable with $MgSO_4$ @ 20 kg ha^{-1} at 20 DAS along with foliar spray of 1% $MgSO_4$ at 40 DAS (T_9), $MgSO_4$ @ 20 kg ha^{-1}in two equal splits at 20 and 40

DAS (T_4) and $MgSO_4$ @ 10 kg ha^{-1} at 20 DAS along with 2% $MgSO_4$ as foliar spray at 40 DAS (T_{10}). The increased grain yield registered in these treatments might be due to the production of more number of panicles m^{-2}, grains $panicle^{-1}$ and production of bold grains with the highest test weight of grains. Compared to control and adhoc recommendations, the treatment T_6 recorded a yield enhancement of 32.35 and 32.23 per cent respectively. Raj *et al*. (2013) reported that application of 20 kg $MgSO_4$ along with recommended dose of N: P: K and FYM registered more number of panicles m^2 and filled grains $panicle^{-1}$. The lowest grain yield registered in adhoc recommendations (T_{13}) might be due to the fact that the entire dose (80 kg ha^{-1}) of $MgSO_4$ was applied at 10 DAS, when the rice root system was not well developed to absorb Mg to its full extent and also the highly mobile nature of Mg in the soil might have caused leaching of $MgSO_4$ from the root zone. Study conducted by Biswas *et al*. (2013) also pointed out the significance of lower dose of $MgSO_4$ for yield enhancement in rice. Straw yield was not significantly influenced by the treatments. Harvest index was followed the same trend as that of grain yield. Economic analysis of the data revealed that $MgSO_4$ @ 40 kg ha^{-1} in two equal splits at 20 and 40 DAS (T_6) recorded the highest B:C ratio and it was on par with the application of $MgSO_4$ @ 20 kg ha^{-1}in two equal splits at 20 and 40 DAS (T_4). These two treatments were statistically superior to other treatments. Srivastava *et al*. (2006) pointed out that application of Mg brought about a marked increase in B: C ratio due to marked increase in grain yield. Khadtare *et al*. (2017) also indicated the higher monetary returns and B:C ratio with $MgSo_4$ application. Though treatment T_9 recorded high grain yield than that of T_4; recorded lesser B:C ratio might be due to the high cost involved in foliar spraying.

The fertilization of $MgSO_4$ had profound influence on yield and yield attributing characters of direct seeded rice. Compared to single application, split application of $MgSO_4$ had significant effect on yield attributes, grain

yield and economics. The income in direct seeded rice can be enhanced by the application of $MgSO_4$ @ 40 kg ha^{-1} in two equal splits at 20 and 40 DAS. This information may benefit the farmers to adopt the time and amount of $MgSO_4$ application in direct seeded rice crop to enhance the grain yield and to have appreciable monetary return.

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