Research Journal of Agricultural Sciences
Volume 14; Issue 01; pp 122–126

Open Access
ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Full Length Research Article

Polyhalite as a Source of Potassium on Dry Matter Production and Nutrient Uptake of Black Gram Cv. ADT 5

P. K. Karthikeyan*[1], R. Ranjani[2], R. Bhuvaneswari[3], S. Rameshkumar[4], D. Gokul[5], K. Swetha Reddy[6] and Ajish Muraleedharan[7]

[1-3, 5-6] Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Chidambaram - 608 002, Tamil Nadu, India
[4, 7] Department of Horticulture, Faculty of Agriculture, Annamalai University, Chidambaram - 608 002, Tamil Nadu, India

Abstract

An experiment was conducted at the farmer's field, Chinakandiyankuppam village, Vriddhachalam taluk, Cuddalore district, Tamil Nadu to evaluate the effect of polyhalite on dry matter production and nutrient uptake of black gram (*Vigna mungo* L.) – cv. ADT-5 during 2021. The experimental soil was loamy sand in texture comes under Arasanatham series. The treatments consisted of graded levels of potassium in two sources (MOP and polyhalite). The experiment was laid out in randomized block design with ten treatments and replicated three times. Each treatment received a standard dose of nitrogen (25 kg ha^{-1}) and phosphorus (50 kg ha^{-1}). As a result of the experiment revealed that the maximum dry matter production (3312 kg ha^{-1}) at harvest, nitrogen uptake (49.15 kg ha^{-1}), phosphorus uptake (5.25 kg ha^{-1}), potassium uptake (20.64 kg ha^{-1}), sulphur uptake (3.75 kg ha^{-1}), calcium uptake (36.21 kg ha^{-1}), magnesium uptake (16.88 kg ha^{-1}) in haulm were significantly improved when 37.5 kg K_2O ha^{-1} was applied as polyhalite. Among the two potassium sources experimented, polyhalite performed significantly than MOP.

Key words: Black gram, Dry matter production, Nutrient uptake, Polyhalite

Black gram (*Vigna mungo* L.) is known as the king of pulse crop and it is one of the most important pulse crops which can be grown in tropical and sub-tropical region. Black gram is native to India and originated from *Phaseolus sublobatus* a wild plant. The protein content of black gram is 26 per cent, which is almost three times that of cereals. Also, milch animals consume it as nutritive fodder. In terms of consumption and production, India is the world's largest supplier and consumer of Black gram. Black gram is very nutritious as it contains a high level of carbohydrate (60 g 100 g^{-1}), protein (20 - 25 g 100 g^{-1}), phosphorus (385 mg 100 g^{-1}), calcium (145 mg 100 g^{-1}) and iron (7.8 mg 100 g^{-1}). Globally, black gram covers 23.48 million hectares with a production level of 653.07 kg ha^{-1}. The total area under black gram in India is around 4.47 million hectares with a production of 2.83 million tonnes and productivity of 632 kg ha^{-1}. In Tamil Nadu, black gram is cultivated in 4.30 lakh hectares with the production of 2.74 lakh tonnes and an average productivity of 637 kg ha^{-1} [1].

Polyhalite, a mineral in evaporate deposits ($K_2 Ca_2 Mg (SO_4)_4 . 2H_2O$) that often occurs with anhydrite and halite. Polyhalite as a potassium, sulphur source and the agronomic performance of polyhalite as a fertilizer is less known, thus improved understanding of its performance is essential owing to demand for alternate cost effective of the nutrient Ca, Mg, S and K resources [2]. Due to its gradual release and sustained nutrient release, polyhalite has the potential to increase the effectiveness of potassium use. In addition, for chloride-sensitive plants, polyhalite might be a better potassium fertilizer than KCl. Plants require potassium and secondary nutrients to develop properly. Apart from activating numerous enzymes, potassium also maintains electrical potential gradients across cell membranes and generates turgor. By keeping above in mind, the present study was designed to assess the impact of polyhalite on dry matter production and nutrient uptake of black gram.

MATERIALS AND METHODS

A field experiment was carried out at the farmer's field, Chinakandiyankuppam village near Vriddhachalam to evaluate the effect of polyhalite on dry matter production and nutrient uptake of black gram (*Vigna mungo* L.) – cv. ADT-5 during 2021. The experimental soil was loamy sand in texture with pH - 7.56, EC - 0.24 dS m^{-1}. The initial soil was low in $KMnO_4$-N

Received: 11 Oct 2022; Revised accepted: 31 Dec 2022; Published online: 16 Jan 2023

Correspondence to: P. K. Karthikeyan, Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Chidambaram - 608 002, Tamil Nadu, India, Tel: +91 9842212222; E-mail: karthikeyan37@hotmail.com

Citation: Karthikeyan PK, Ranjani R, Bhuvaneswari R, Rameshkumar S, Gokul D, Reddy KS, Muraleedharan A. 2023. Polyhalite as a source of potassium on dry matter production and nutrient uptake of black gram Cv. ADT 5. *Res. Jr. Agril Sci*. 14(1): 122-126.

(181.3 kg ha^{-1}), medium in Olsen-P (16.1 kg ha^{-1}), medium in NH_4OAc-K (194.1 kg ha^{-1}) and sufficient in available sulphur (12.89 mg kg^{-1}). The available calcium and magnesium were 5.78 C mol (p$^+$) kg^{-1} and 2.49 C mol (p$^+$) kg^{-1} respectively. The experiment was laid out in randomized block design consisting of 10 treatments viz., T_1 - absolute control, T_2 - control (-K), T_3 - 12.5 kg K_2O ha^{-1} as MOP, T_4 - 25 kg K_2O ha^{-1} as MOP, T_5 - 37.5 kg K_2O ha^{-1} as MOP, T_6 - 50 kg K_2O ha^{-1} as MOP, T_7 - 12.5 kg K_2O ha^{-1} as polyhalite, T_8 - 25 kg K_2O ha^{-1} as polyhalite, T_9 - 37.5 kg K_2O ha^{-1}as polyhalite, T_{10} - 50 kg K_2O ha^{-1}as polyhalite. Recommended dose of nitrogen (25 kg ha^{-1}) and phosphorus (50 kg ha^{-1}) were applied to all the treatments uniformly except absolute control. The dry matter production and nutrient uptake were examined at 30, 45 DAS and at harvest stage. The nutrient uptake was calculated from dry matter production and nutrient content at different growth stages and harvest stage of the crop. The weather data for growing periods of black gram were presented in (Fig 1).

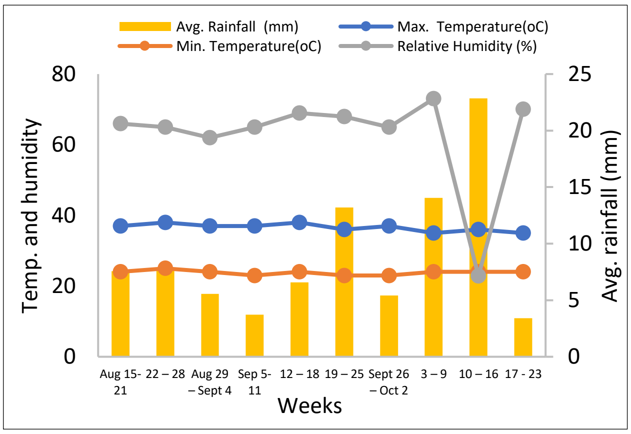

Fig 1 The weather data for growing periods of black (Aug 15 to Oct 23, 2022)

RESULTS AND DISCUSSION

Dry matter production

The dry matter production (DMP) of black gram was significantly enhanced by application of graded doses of potassium applied through KCl or polyhalite over control (Table 1). The dry matter production ranged from 874 to 1399 kg ha^{-1} (30 DAS), 1132 to 1972 kg ha^{-1} (45 DAS) and 1985 to 3312 kg ha^{-1} (harvest). The dry matter production increased with potassium doses irrespective of potassium sources. Irrespective of potassium sources, a significant highest dry matter production of 1399, 1972 and 3312 kg ha^{-1} at 30, 45 DAS and at harvest respectively, was recorded with the application of 37.5 kg K_2O ha^{-1} through polyhalite (T_9). However, application of potassium either through KCl or polyhalite at 37.5 kg K_2O ha^{-1} was significantly superior to application of potassium at 12.5, 25 and 50 kg K_2O ha^{-1} applied either through KCl or polyhalite. The lowest dry matter production (1132 kg ha^{-1}) at harvest stage was recorded in absolute control (T_1). The application of polyhalite resulted in greater dry matter production compared to black gram that was fertilized with muriate of potash. A positive response of dry matter production by the plants to polyhalite application was observed, reaching a maximum of dry matter [3-4]. The beneficial effect of fertilizer potassium on dry matter production and distribution in plants was probably associated with the maintenance of better water relations in the plants due to potassium application by Islam *et al.* [5]. The dry matter in different plant parts and mineral ion accumulation in different plant parts [6]. Under optimum levels of potassium, dry matter production was increased indicating the possible role of potassium which was evident from higher N, P and K content of leaves by Tak *et al.* [7].

Table 1 Impact of polyhalite on dry matter production of black gram

Treatments	Dry matter production (kg ha^{-1})		
	30 DAS	45 DAS	At harvest
T_1	874	1132	1985
T_2	947	1392	2162
T_3	1003	1484	2318
T_4	1144	1642	2614
T_5	1359	1912	3192
T_6	1278	1792	2953
T_7	1074	1569	2473
T_8	1216	1714	2780
T_9	1399	1972	3312
T_{10}	1320	1852	3073
SEd	18.26	28.5	54.9
CD @ 5%	38.36	59.6	115.5

Nitrogen uptake

At all the growth stages, the uptake of N was significantly increased with the application of graded doses of potassium applied through KCl and polyhalite over control (without potassium) and absolute control. The data are furnished in the (Table 2). The nitrogen uptake ranged from 18.53 to 29.66 kg ha^{-1} (30 DAS), 23.89 to 41.79 kg ha^{-1} (45 DAS), 25.31 to 49.15 kg ha^{-1} (haulm) and 23.17 to 48.64 kg ha^{-1} (seed). Among the treatment, application of 37.5 kg K_2O ha^{-1} through polyhalite (T_9) ranked best by registering the highest N uptake of 29.66 kg ha^{-1} (30 DAS), 41.79 kg ha^{-1} (45 DAS) and 49.15 kg ha^{-1} (haulm) and 48.64 kg ha^{-1} (seed). However, application of potassium either through KCl or polyhalite at 37.5 kg K_2O ha^{-1} was significantly superior to application of potassium at 12.5, 25 and 50 kg K_2O ha^{-1} applied either through KCl or polyhalite. The lowest N uptake status of 18.53 kg ha^{-1} (30 DAS), 23.89 kg ha^{-1} (45 DAS), 25.31 kg ha^{-1} (Haulm) and 23.17 kg ha^{-1} (Seed) were recorded in absolute control (T_1). This might be due to possible that the extra K nutrition from polyhalite, an organic source, increased microbial activity, which in turn increased nitrogen fixation and abundant plant and root growth, which in turn increased total nitrogen uptake [8-9]. The regression model between the nitrogen uptake in seed and dry matter production is $y = 54.343x + 673.88$, $R^2 = 0.9948$ (Fig 2).

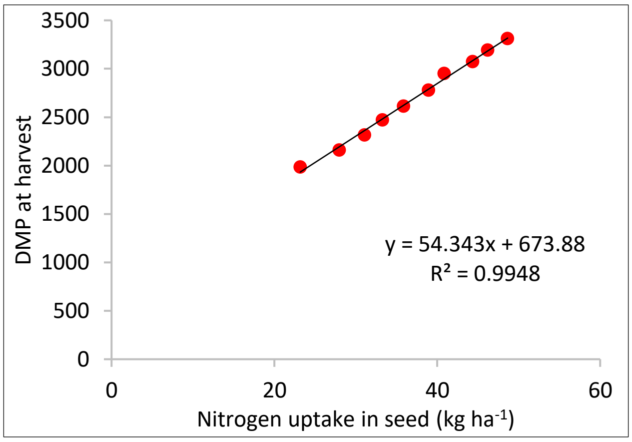

Fig 2 Relationship between nitrogen uptake (kg ha^{-1}) and dry matter production

Phosphorus uptake

The influence of various treatments in enhancing the uptake of P was significantly increased with the application of graded doses of potassium applied through KCl and polyhalite over control (K) and absolute control (Table 2). The phosphorus uptake ranged from 3.58 to 5.74 kg ha^{-1} (30 DAS), 4.41 to 7.69 kg ha^{-1} (45 DAS), 3.37 to 5.25 kg ha^{-1} (haulm) and 1.94 to 3.60 kg ha^{-1} (seed). Among the treatment experimented, application of 37.5 kg K_2O ha^{-1} through polyhalite (T_9) ranked best by registering the highest P uptake of 5.74 kg ha^{-1} (30 DAS), 7.69 kg ha^{-1} (45 DAS), 5.25 kg ha^{-1} (haulm) and 3.60 kg ha^{-1} (seed). However, application of potassium either through KCl or polyhalite at 37.5 kg K_2O ha^{-1} was significantly superior to application of potassium at 12.5, 25 and 50 kg K_2O ha^{-1}applied either through KCl or polyhalite. The lowest P uptake status 3.58 kg ha^{-1} (30 DAS), 4.41 kg ha^{-1} (45 DAS), 3.37 kg ha^{-1} (haulm) and 1.94 kg ha^{-1} (seed) were recorded in absolute control (T_1). The availability of phosphate-solubilizing bacteria may have risen in the presence of nutrients, improving overall phosphorous intake [10]. This was aptly supported by the establishment of significant linear relationship between phosphorus uptake in seed and dry matter production ($y = 851.4x + 223.1$, $R^2 = 0.9841$) (Fig 3).

Table 2 Impact of polyhalite on nitrogen and phosphorus uptake of black gram

Treatments	Nitrogen uptake (kg ha^{-1})				Phosphorus uptake (kg ha^{-1})			
	30 DAS	45 DAS	Haulm	Seed	30 DAS	45 DAS	Haulm	Seed
T_1	18.53	23.89	25.31	23.17	3.58	4.41	3.37	1.94
T_2	20.08	29.39	28.93	27.95	3.88	5.43	3.65	2.31
T_3	21.26	31.34	31.24	31.07	4.11	5.79	3.85	2.53
T_4	24.25	34.71	36.31	35.85	4.69	6.40	4.29	2.88
T_5	28.81	40.50	46.70	46.20	5.57	7.46	5.09	3.45
T_6	27.09	37.92	41.87	40.86	5.24	6.99	4.75	3.16
T_7	22.77	33.15	33.71	33.28	4.40	6.12	4.07	2.72
T_8	25.78	36.25	38.99	38.92	4.99	6.68	4.51	3.03
T_9	29.66	41.79	49.15	48.64	5.74	7.69	5.25	3.60
T_{10}	27.98	39.21	44.40	44.36	5.41	7.22	4.91	3.31
SEd	0.35	0.50	0.91	0.81	0.07	0.10	0.07	0.06
CD @ 5%	0.73	1.05	1.92	1.72	0.16	0.21	0.15	0.13

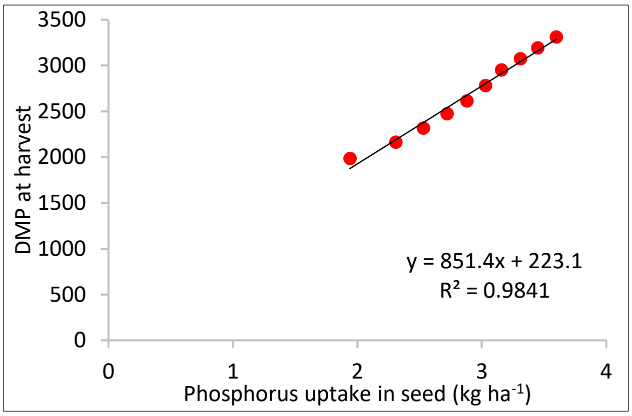

Fig 3 Relationship between phosphorus uptake (kg ha^{-1}) and dry matter production

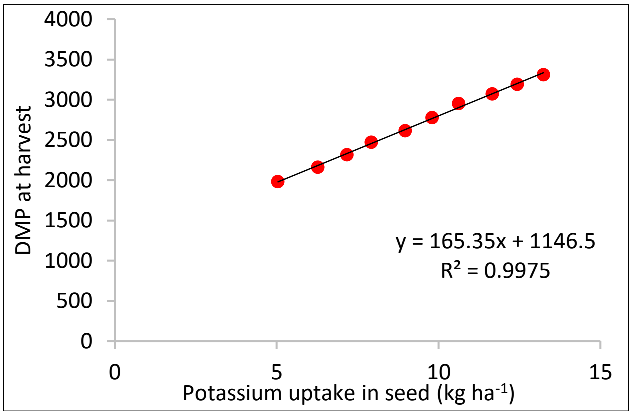

Fig 4 Relationship between potassium uptake (kg ha^{-1}) and dry matter production

Table 3 Impact of polyhalite on potassium and sulphur uptake of black gram

Treatments	Potassium uptake (kg ha^{-1})				Sulphur uptake (kg ha^{-1})			
	30 DAS	45 DAS	Haulm	Seed	30 DAS	45 DAS	Haulm	Seed
T_1	9.44	12.45	11.09	5.04	0.88	1.02	1.21	0.47
T_2	10.23	15.31	12.12	6.27	1.02	1.39	1.56	0.65
T_3	10.83	16.32	12.93	7.17	1.21	1.63	1.79	0.81
T_4	12.36	18.06	14.71	8.97	1.61	2.13	2.30	1.04
T_5	14.95	21.03	19.08	12.43	2.45	3.44	3.45	1.66
T_6	13.80	19.71	16.61	10.62	2.05	2.69	2.88	1.27
T_7	11.60	17.26	13.8	7.92	1.39	1.88	2.03	0.93
T_8	13.13	18.85	15.62	9.80	1.82	2.40	2.58	1.14
T_9	15.53	21.69	20.64	13.24	2.64	3.94	3.75	1.87
T_{10}	14.39	20.37	17.55	11.66	2.27	2.96	3.16	1.46
SEd	0.19	0.28	0.38	0.22	0.06	0.11	0.10	0.04
CD @ 5%	0.39	0.59	0.80	0.47	0.14	0.24	0.22	0.08

Potassium uptake

The effect due to application of potassium through KCl or polyhalite resulted in significant increase in potassium uptake was well evidenced in the present investigation. The data are furnished in the (Table 3). The potassium uptake ranged from 9.44 to 15.53 kg ha^{-1} (30 DAS), 12.45 to 21.69 kg ha^{-1} (45 DAS), 11.09 to 20.64 kg ha^{-1} (haulm) and 5.04 to 13.24 kg ha^{-1} (seed). Among the different treatments, application of 37.5 kg K_2O ha^{-1} through polyhalite (T_9) ranked best by registering the highest K uptake of 15.53 kg ha^{-1} (30 DAS), 21.69 kg ha^{-1} (45 DAS), 20.64 kg ha^{-1} (haulm) and 13.24 kg ha^{-1} (seed). However, potassium application at 37.5 kg K_2O ha^{-1} applied either through KCl or polyhalite was considerably better than potassium application at 12.5, 25 and 50 kg K_2O ha^{-1} applied either through KCl or polyhalite. Among the two potassium sources, the polyhalite was performed significantly than KCl. The lowest K uptake status 9.44 kg ha^{-1} (30 DAS), 12.45 kg ha^{-1} (45 DAS), 11.09 kg ha^{-1} (haulm) and 5.04 kg ha^{-1} (seed) were recorded in absolute control (T_1). Potassium supplementation and the abundant root and plant growth brought on by extra nutrients provided by KCl and polyhalite may be the causes of the increased potassium content which leads to the increased potassium uptake [11]. Different fertilizer treatments had various effect on nutrient availability and distribution among Black gram at harvest. Polyhalite application increased the nutrient uptake in grain, haulm and plants [12-13].

The regression model between the potassium uptake in seed and dry matter production is y = 165.35x + 1146.5, R^2 = 0.9975 (Fig 4).

Sulphur uptake

The results due to application of different levels of polyhalite resulted in significant increase in sulphur uptake by Black gram over control (-K) and absolute control (Table 3). From the table the maximum sulphur uptake of 2.64 kg ha^{-1} (30 DAS), 3.94 kg ha^{-1} (45 DAS), 3.75 kg ha^{-1} (haulm) and 1.87 kg ha^{-1} (seed) were recorded in the treatment with application of 37.5 kg K_2O ha^{-1} through polyhalite (T_9). However, application of potassium at 37.5 kg K_2O ha^{-1} applied either through KCl or polyhalite was considerably better than potassium application at 12.5, 25 and 50 kg K_2O ha^{-1} applied either through KCl or polyhalite. The lowest sulphur uptake was recorded in absolute control (T_1). The regression model between the sulphur uptake in seed and dry matter production is y = 1002.7x + 1553.1, R^2 = 0.9746. (Fig 5). The increased sulphur uptake due to the supplementation of sulphur from polyhalite resulted in increase in sulphur uptake in grain and haulm. The application of sulphur has improved the availability of other nutrients that are crucial for the growth and development of plants, in addition to the sulphur itself [14-15].

Calcium uptake

Application of polyhalite resulted in significant increase in calcium uptake by black gram and the data are furnished in (Table 4). The calcium uptake ranged from 3.06 to 5.88 kg ha^{-1} (30 DAS), 10.19 to 28.20 kg ha^{-1} (45 DAS), 19.28 to 36.21 kg ha^{-1} (haulm) and 0.74 to 2.88 kg ha^{-1} (seed). Among the treatments tried, application of 37.5 kg K_2O ha^{-1} through polyhalite (T_9) significantly increased the calcium uptake at different stages. The lowest calcium uptake was recorded in absolute control (T_1). The increase in calcium uptake was due to the increased above ground biomass and calcium content that resulted from potassium application through polyhalite [16]. This was aptly supported by the establishment of significant linear relationship between calcium uptake in seed and dry matter production. (y = 618.28x + 1581.3, R^2 = 0.9948) (Fig 6).

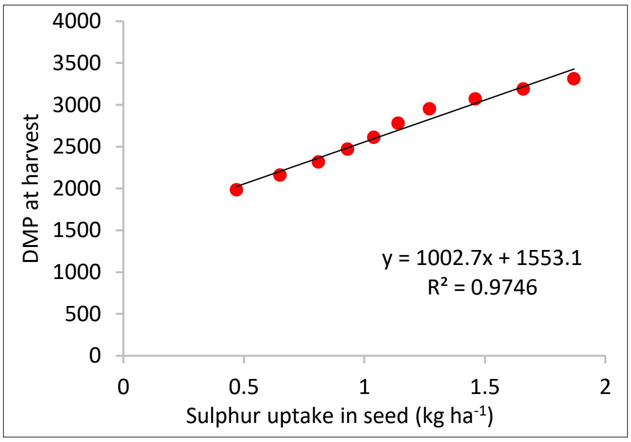

Fig 5 Relationship between sulphur uptake (kg ha^{-1}) and dry matter production

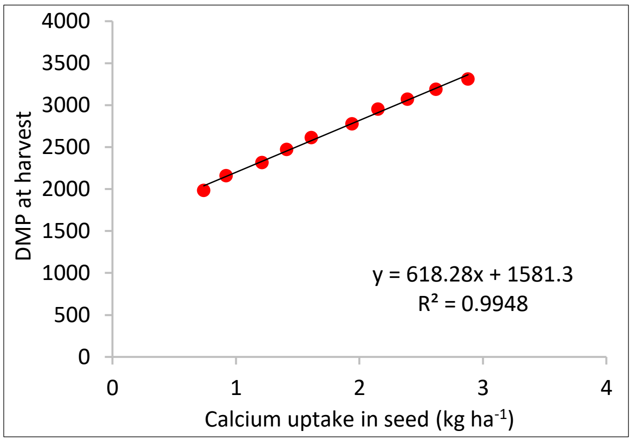

Fig 6 Relationship between calcium uptake (kg ha^{-1}) and dry matter production

Table 4 Impact of polyhalite on calcium and magnesium uptake of black gram

Treatments	Calcium uptake (kg ha^{-1})				Magnesium uptake (kg ha^{-1})			
	30 DAS	45 DAS	Haulm	Seed	30 DAS	45 DAS	Haulm	Seed
T_1	3.06	10.19	19.28	0.74	2.53	6.79	7.23	0.85
T_2	3.31	13.22	21.24	0.92	2.75	8.77	8.21	1.11
T_3	3.61	14.99	23.25	1.21	2.91	9.79	9.08	1.31
T_4	4.23	18.23	26.81	1.61	3.43	11.82	11.03	1.73
T_5	5.57	26.01	34.34	2.62	4.21	16.06	15.81	2.49
T_6	4.98	21.86	30.68	2.15	3.83	13.98	13.22	2.15
T_7	3.87	16.63	24.99	1.41	3.22	10.83	10.03	1.52
T_8	4.62	19.88	28.68	1.94	3.65	12.86	12.08	1.94
T_9	5.88	28.20	36.21	2.88	4.34	16.96	16.88	2.73
T_{10}	5.28	23.89	32.47	2.39	4.09	15.00	14.57	2.25
SEd	0.10	0.42	0.46	0.05	0.05	0.27	0.26	0.04
CD @ 5%	0.22	0.90	0.98	0.11	0.11	0.57	0.56	0.09

Magnesium uptake

The application of polyhalite and KCl significantly improved the magnesium uptake of black gram at 30, 45 DAS and at harvest stage (Table 4). The magnesium uptake ranged from 2.53 to 4.34 kg ha^{-1} (30 DAS), 6.79 to 16.96 kg ha^{-1} (45 DAS), 7.23 to 16.88 kg ha^{-1} (Haulm) and 0.85 to 2.73 kg ha^{-1} (Seed). Among the treatments experimented, application of 37.5 kg K_2O ha^{-1} through polyhalite (T_9) registered the highest magnesium uptake of 4.34 kg ha^{-1} (30 DAS), 16.96 kg ha^{-1} (45 DAS), 16.88 kg ha^{-1} (Haulm) and 2.73 kg ha^{-1} (Seed). However, potassium application at 37.5 kg K_2O ha^{-1} applied either through KCl or polyhalite was considerably better than potassium application at 12.5, 25 and 50 kg K_2O ha^{-1} applied either through KCl or polyhalite. The lowest Magnesium uptake of 2.53 kg ha^{-1} (30 DAS), 6.79 kg ha^{-1} (45 DAS), 7.23 kg ha^{-1} (Haulm) and 0.85 kg ha^{-1} (Seed) were recorded in absolute control (T_1). This might be due to magnesium availability from polyhalite was high and sufficient for normal plant growth, which resulted in much greater magnesium uptake under soluble fertilizer. The increases in magnesium content and dry matter production due to application of polyhalite resulted in higher uptake of magnesium [17]. This was aptly supported by the establishment of significant linear relationship between magnesium uptake in seed and dry matter production. ($y = 733.57x + 1359.9$, $R^2 = 0.9961$) (Fig 7).

CONCLUSION

The field experiment was concluded that application of polyhalite as a potassium source for black gram than KCl. Polyhalite contains potassium and sulphur which is an essential nutrient for black gram production. From this study, the application of 37.5 kg K_2O ha^{-1} through polyhalite recorded the highest dry matter production and nutrient uptake in black gram seed and haulm. The increases in nutrient content due to the application of potassium at appropriate growth stages lead to increase in nutrient availability, higher rate of photosynthesis which finally resulted in nutrient uptake of black gram.

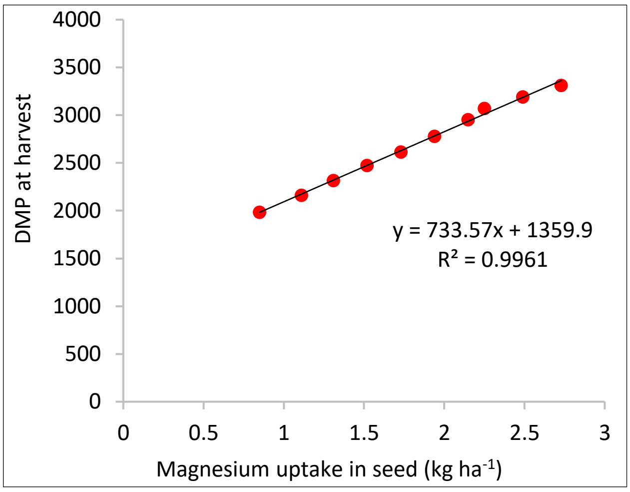

Fig 7 Relationship between magnesium uptake (kg ha^{-1}) and dry matter production

LITERATURE CITED

1. Indiastat. 2019. Online data base. *In*: http://www.indiastat.com.
2. Molin SJD, Nascimento CO, Teixeira PC, Benites VDM. 2020. Polyhalite as a potassium and multi nutrient source for plant nutrition. *Archives of Agronomy and Soil Science* 66(5): 667-678.
3. Yermiyahu U, Zipori I, Faingold I, Yusopov L, Faust N, Bar-Tal A. 2017. Polyhalite as a multi nutrient fertilizer–potassium, magnesium, calcium and sulfate. *Israel Jr. Plant Sci*. 64(3/4): 145-157.
4. Foxhoven SW. 2019. Polyhalite alters the uptake and partitioning of mineral nutrients in corn. *M. Sc. Thesis*, University of Illinois, Urbana.
5. Islam MS, Haque MM, Khan MM, Hidaka T, Karim MA. 2004. Effect of fertilizer potassium on growth, yield and water relations of bushbean (*Phaseolus vulgaris* L.) under water stress conditions. *Japanese Jr. Trop. Agric.* 48(1): 1-9.
6. Karim MA, Raptan PK, Hamid A, Khaliq QA, Solaiman ARM, Ahmed JU. 2001. Salinity tolerance of blackgram and mungbean: I. Dry matter accumulation in different plant parts. II. Mineral ions accumulation in different plant parts. *Korean Jr. Crop Sci.* 46(5): 380-394.
7. Tak HI, Babalola OO, Huyser MH, Inam A. 2013. Urban wastewater irrigation and its effect on growth, photosynthesis and yield of chickpea under different doses of potassium. *Soil Sci. Plant Nutri.* 59(2): 156-167.
8. Dutta R, Gogoi PK, Deka NC. 2003. Effect of levels of lime and potassium on nutrient uptake and residual soil fertility in groundnut (*Arachis hypogaea* L.). *Crop Research* 26(3): 420-423.
9. Rathore SS, Chaudhary DR, Vaisya LK, Shekhawat K, Bhatt BP. 2014. Schoenite and potassium sulphate: Indigenous potassic fertilizer for rainfed groundnut (*Arachis hypogaea* L.). *Indian Jr. Traditional Knowledge* 13(1): 222-226.
10. Gogoi PK, Choudhury RM, Dutta R, Deka NC. 2000. Effect of levels of lime and nitrogen on production of groundnut (*Arachis hypogaea* L.). *Crop Research* 20(2): 274-278.
11. Hadwani GJ, Gundalia JD. 2005. Effect of N, P and K levels on yield, nutrient content, uptake and quality of summer groundnut grown on *Typic haplustepts*. *Jr. Indian Soc. Soil Science* 53(1): 125-128.
12. Anac D, Eryuce N, Ozkan CF, Simsek M, Demirtas EL, Asri F, Guven D, Ari N. 2019. Effect of different potassium and sulfate fertilizer types on cabbage yield and quality. *Electronic International Fertilizer Correspondent (e-ifc)* (56): 11-18.
13. Ozkan CF, Anac D, Eryuce N, Demirtas EL, Asri FO, Guven D, Simsek M, Ari N. 2018. Effect of different potassium and sulfur fertilizers on onion (*Allium cepa* L.) yield and quality. *Electronic International Fertilizer Correspondent (e-ifc)* (53): 16-24.
14. Prajapat K, Shivran AC, Yadav LR, Choudhary GL. 2011. Growth, production potential and economics of mungbean as influenced by intercropping systems and sulphur levels. *Jr. Food Leg.* 24(4): 330-331.
15. Kumawat SR, Khistriya MK, Yadav SL, Manoj K. 2014. Effect of sulphur and phosphorus on growth and yield attributes on summer green gram [*Vigna radiata* (L.) *Wilczek*]. *Intl. Jr. Agric. Sciences* 10(2): 770-773.
16. Yi L, Ming L, Zhi Y, Xin-ping C, Li G, Dun-yi L. 2021. Enrichment of compound NPK fertilizer with polyhalite enhances pepper (*Capsicum annuum*) yield and quality on poor yellow soils in Southwest China. *International Fertilizer Correspondent (e-ifc)* (65): 12-23.
17. Vale F, Serio DR. 2017. Introducing polyhalite to Brazil: first stepsof a new fertilizer. *IPI e-ifc* 48: 3-11.