Journal of Applied and Natural Science
15(1), 29 - 33 (2023)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Evaluation of polyhalite on growth, yield attributes and yield of blackgram (*Vigna mungo* L.)

P. K. Karthikeyan
Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Chidambaram- 608002 (Tamil Nadu), India
R. Ranjani
Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Chidambaram- 608002 (Tamil Nadu), India
D. Gokul
Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Chidambaram- 608002 (Tamil Nadu), India
K. Swetha Reddy
Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Chidambaram- 608002 (Tamil Nadu), India
R Bhuvaneswari
Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Chidambaram- 608002 (Tamil Nadu), India
Ajish Muraleedharan
Department of Horticulture, Faculty of Agriculture, Annamalai University, Chidambaram- 608002 (Tamil Nadu), India

*Corresponding author. E mail: pkkarthikeyan7777@gmail.com

Article Info
https://doi.org/10.31018/jans.v15i1.4105
Received: October 1, 2022
Revised: January 12. 2023
Accepted: January 17, 2023

How to Cite
Karthikeyan, P. K. *et al.* (2023). Evaluation of polyhalite on growth, yield attributes and yield of blackgram (*Vigna mungo* L.). *Journal of Applied and Natural Science*, 15(1), 29 - 33. https://doi.org/10.31018/jans.v15i1.4105

Abstract
Potassium is involved in a diverse range of processes within plants that are needed for their growth, yield and better quality. The polyhalite as a hydrated evaporate mineral that can be used directly as a source of potassic fertilizer. However, research on polyhalite's appropriateness and effectiveness, the present investigation aimed to evaluate the effect of polyhalite on growth, yield attributes, and yield of blackgram variety ADT 5 at Chinnakandiankuppam village, Vriddhachalam, Cuddalore district, Tamil Nadu, during 2021. The experiment was laid out in randomized block design consisting of ten treatments viz., T_1 (absolute control), T_2 (-K), T_3 (12.5 kg K_2O ha^{-1} as muriate of potash (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). The experiment revealed that the application of 37.5 kg K_2O ha^{-1} as polyhalite (T_9) significantly (5%) enhanced the growth attributes (plant height (38.7 cm), number of branches $plant^{-1}$ (12.97), leaf area index (2.13), number of nodules $plant^{-1}$ (18.76) and dry matter production (1972 hg ha^{-1}), yield attributes (pod length (8.21 cm), number of pods $plant^{-1}$ (20.05), number of seeds pod^{-1} (7.14) and test weight (3.53 g)) and grain yield (1439 kg ha^{-1}), haulm yield (1876 kg ha^{-1}) of blackgram. Thus the study would be helpful to farmers for yield maximization of blackgram through polyhalite as potassic fertilizer.

Keywords: Blackgram, Growth, Muriate of potash, Polyhalite, Yield

INTRODUCTION

In many parts of the world, pulses are edible fruits and seeds of pod-bearing plants from the Leguminosae family. Their protein content ranges from 20 - 40%. Due to their low cost, pulses are often thought of as "poor man's meat". Though pulse crops are very popular in the developing world, there is a massive gap in productivity. The total world acreage under pulses is about 85.4 million hectares, with a production of 87.4 million tonnes at 1023 kg ha^{-1} yield level. In India, pulses are cultivated under an area of 287.83 lakh hectares with a production of 254.63 lakh tonnes and a productivity of 885 kg ha^{-1}. The total area under pulses in Tamil Nadu

is 8.03 lakh hectares with a production of 4.72 lakh tonnes and productivity of 588 kg ha^{-1} (DES, Ministry of Agriculture & FW (DAC & FW), Govt. of India (2021). The improved cultivars and modern production techniques, pulses productivity can also be doubled (Pankaj and Dewangan, 2017). The blackgram (*Vigna mungo* L.) is known as the king of pulses and is widely grown in tropical and sub-tropical regions. In India, blackgram is also known as "Urd" and "Mash". (Kumar *et al*., 2018). Globally, blackgram covers 23.48 million hectares with a production level of 653.07 kg ha^{-1}. India's average of total area under blackgram is around 41.43 lakh hectares with a production of 22.30 lakh tonnes and productivity of 538 kg ha^{-1}. In Tamil Nadu, blackgram is cultivated in 4.02 lakh hectares with a production of 2.25 lakh tonnes and average productivity of 559 kg ha^{-1} (DES, Ministry of Agriculture & FW (DAC & FW), Govt. of India (2021). As fertility management plays a vital role in increasing the seed yield in pulse crops, it is among the most important factors that limit crop production on exhausted soils (Chandrasekhar and Bangarusamy, 2003).

In many developing countries, including India, potassium application has been neglected, leading to soil K depletion in agricultural ecosystems and crop yield declines Plants require potassium for proper development. Polyhalite has been explored in North Yorkshire in the United Kingdom as an alternate potassium source (Kemp *et al.,* 2016). Polyhalite, a sulphur mineral in evaporate deposits ($K_2Ca_2Mg(SO_4)_4$. $2H_2O$), often occurs with anhydrite and halite. The composition of polyhalite is 19.2% sulphate, 14% potassium sulphate, 3.6% magnesium sulphate, and 11.6% calcium sulphate. Due to its low chloride content, it can be used on crops sensitive to chloride. Potassium was the first nutrient identified in polyhalite. The main cation in plant tissue is potassium, one of the most abundant plant nutrients (Nieves-Cordones *et al.,* 2016). Calcium and magnesium are also contained in polyhalite, but are less common. The fourth major nutrient for plant growth is sulphur, an essential but neglected nutrient (Yermiyahu *et al*., 2017). The blackgram has a demand for potassium for higher growth and yield. To keep the above facts in mind, a present study was designed to investigate the effects of increasing rates of polyhalite on growth parameters, yield parameters and yield of black gram variety ADT 5.

MATERIALS AND METHODS

An experiment was conducted at Chinnakandiyankuppam near Vriddhachalam in the Cuddalore district, Tamil Nadu. It is located at 11°52' N latitude and 79°33'E longitude, it is 45 meters above mean sea level. It belongs to the northern agroclimatic zone of Tamil Nadu. At Chinnakandiyankuppam, the average annual rainfall is 1204.1 millimetres. There is a mean maximum temperature fluctuation of 35 to 38°C with a mean temperature of 36.5°C, while the mean minimum temperature fluctuates from 23 to 25°C with a mean temperature of 24°C. There is a mean relative humidity of 67.5% with the highest being 73% during October and the lowest being 62% during September. In this study, three replications and ten treatments were assigned in a randomized block design *viz.,* T_1 (absolute control), T_2 (K-control), T_3 (12.5 kg K_2O ha^{-1} as muriate of potash (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 doses of nitrogen (25 kg ha^{-1}) and phosphorus (50 kg ha^{-1}) were uniformly applied to all the treatments. The soils of Chinnakandiankuppam village were found to contain soil separates of 77.1, 14.3 and 5.9 % sand, silt and clay, respectively. The soils were classified under the textural class loamy sand (Typic Ustropepts). An initial soil sample had the pH, electrical conductivity (Jackson, 1973), and cation exchange capacity (neutral normal ammonium acetate method by Piper, 1966) of 7.56, 0.24 dS m^{-1}, 13.57 C mol (p+) kg^{-1}, respectively. Organic carbon content of the soil (Chromic acid wet digestion method by Walkley and Black, 1934) was 0.48 g kg^{-1}. Available N (Alkaline permanganate method by Subbiah and Asija, 1956), available P (Ascorbic acid blue method by Watanabe and Olsen, 1965) and available K (Neutral normal ammonium acetate extraction by Stanford and English 1949) of the soil was 196.3 kg ha^{-1}, 16.1 kg ha^{-1}, 194.1 kg ha^{-1}, respectively. The available sulphur (Turbidimetric method by Chesnin and Yien, 1951) was 13.89 mg kg^{-1} and the exchangeable calcium and magnesium (Versenate method by Jackson, 1973) were 5.78 C mol (p+) kg^{-1} and 2.49 C mol (p+) kg^{-1} respectively.

Black gram variety ADT-5 was selected for sowing. The sowing was done at a spacing 30 × 10 cm. Whenever necessary, gaps were filled in to maintain plant populations. Hand hoes were used for weeding. Two hoeings were done, the first on 15 DAS and the second on 30 DAS. Plant protection measures were taken based on the needs of the plants. For each plot, the entire plants were pulled and bundled separately. Plants were then bundled and dried under the sun. Dry weight was measured at 14 per cent moisture level after the grains were cleaned, dried, and weighed. Grain and haulm yields were measured plot-by-plot and expressed as kg ha^{-1}. The data pertaining to growth, yield attributes and yield were analyzed statistically by AGRES software to interpret the results.

RESULTS AND DISCUSSION

Growth characters

A graded dose of potassium was applied through either muriate of potash or polyhalite and showed significant benefits over K- control and absolute control for blackgram growth. Blackgram exhibited increased growth characteristics when potassium was applied through in the form of MOP (T_3, T_4, T_5 and T_6) and polyhalite (T_7, T_8, T_9 and T_{10}) (Table 1). As compared with other treatments, polyhalite (T_9) with 37.5 kg K_2O ha^{-1} coupled with recommended doses of N and P significantly (5%) increased blackgram plant height (38.7 cm), leaf area index (2.13), number of branches $plant^{-1}$ (12.97), number of nodules $plant^{-1}$(18.76) and dry matter production (1972 kg ha^{-1}) among various growth characteristics. A higher potassium application increased the chlorophyll content of the blackgram. As the result of applying 50 kg of K_2O ha^{-1} as polyhalite (T_{10}) recorded highest chlorophyll content (47.27 SPAD reading at 45 DAS) and it was on par with muriate of potash application (T_6). The lowest growth characteristics were found in absolute control (T_1). A significant increase in growth characteristics was observed when potassium as polyhalite was applied instead of muriate of potash. It showed higher growth characteristics when fertilized with polyhalite. Blackgram developed much faster when treated with polyhalite fertilizers, and calcium, magnesium, and sulphur were supplied to enhance its growth and development. Zhao *et al.* (2020) stated that the application of polyhalite fertilizers, polysulphate at budding and MegaPoly at fruit enlargement, demonstrated remarkable potential to enhance kiwi fruit yield. The potassium treatment through polyhalite enhanced yield and quality of kiwi fruit over all other treatments. According to Navitha *et al.* (2019), the application of potassium as polyhalite significantly increased plant height, number of branches, stem girth, clusters and fruits, number of flowers, fruit weight and yield of tomato as compared to muriate of potash and control. Among the treatments, application of 125 per cent soil test-based potassium through polyhalite surpassed all the other treatments in terms of growth and yield parameters.

Yield attributes

Application of potassium through muriate of potash or polyhalite resulted in a significant increase in yield attributes of black gram over (-K) control and absolute control (Table 2). The highest values for yield attributes like pod length (8.21 cm), number of pods $plant^{-1}$ (20.05), number of seeds pod^{-1} (7.14) and test weight (3.53 g) were recorded with the application of 37.5 kg K_2O ha^{-1} as polyhalite (T_9). However, the application of potassium either through muriate of potash 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 muriate of potash or polyhalite. Absolute control (T_1) recorded the lowest yield attributes. A potassium application in favourable physiological soil conditions has resulted in accelerated rooting, higher LAI, and increased pre- and postflowering photosynthesis and yield attributes. By fertilizing with polyhalite, yields are increased, grain characteristics were improved, yield parameters are improved, and plants grow taller and healthier. In addition, Rosa *et al.* (2020) reported that a single application of potashplus, a granular blend of polyhalite supplies all potassium and sulphur requirements and muriate of potash supply potassium on soybean crop, it is significantly faster than single superphosphate and therefore increases the pro-

Table 1. Effect of different levels of muriate of potash and polyhalite on growth characters of blackgram

Treatments	Plant height (cm)	Number of branches $plant^{-1}$	Leaf Area Index (LAI)	Chlorophyll content (SPAD reading)	No. of nodules $plant^{-1}$	DMP (kg ha^{-1}) at 45 DAS
T_1 - Absolute control	24.4	7.91	1.59	30.77	9.42	1132
T_2* - Control (-K)	26.7	8.45	1.65	32.82	10.49	1392
T_3* - 12.5 kg of K_2O ha^{-1} as MOP	28.1	9.01	1.71	34.74	11.61	1484
T_4* -25 kg of K_2O ha^{-1} as MOP	30.5	10.12	1.83	38.66	13.77	1642
T_5* - 37.5 kg of K_2O ha^{-1} as MOP	37.3	12.37	2.07	42.52	17.64	1912
T_6* - 50 kg of K_2O ha^{-1} as MOP	33.2	11.25	1.95	46.36	15.76	1792
T_7* - 12.5 kg of K_2O ha^{-1} as polyhalite	29.3	9.55	1.77	36.71	12.69	1569
T_8* - 25 kg of K_2O ha^{-1} as polyhalite	31.7	10.68	1.89	40.59	14.89	1714
T_9* - 37.5 kg of K_2O ha^{-1} as polyhalite	38.7	12.97	2.13	43.45	18.76	1972
T_{10}*-50 kg of K_2O ha^{-1} as polyhalite	35.9	11.82	2.01	47.27	16.68	1852
$S.E_d$	0.50	0.22	0.03	0.69	0.20	28.5
C.D (0.05)	1.06	0.47	0.06	1.46	0.43	59.6

* RDF (N and P) common for all treatments

Table 2. Effect of different levels of muriate of potash and polyhalite on yield attributes of blackgram

Treatments	Pod length (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	Test weight (g)
T_1 - Absolute control	6.49	15.58	5.39	2.78
T_2* - Control (-K)	6.67	16.10	5.60	3.10
T_3* - 12.5 kg of K_2O ha^{-1} as MOP	6.86	16.50	5.79	3.25
T_4* -25 kg of K_2O ha^{-1} as MOP	7.24	17.54	6.18	3.33
T_5* - 37.5 kg of K_2O ha^{-1} as MOP	8.01	19.44	6.94	3.49
T_6* - 50 kg of K_2O ha^{-1} as MOP	7.63	18.54	6.56	3.41
T_7* - 12.5 kg of K_2O ha^{-1} as polyhalite	7.05	17.02	5.99	3.29
T_8* - 25 kg of K_2O ha^{-1} as polyhalite	7.44	18.09	6.36	3.37
T_9* - 37.5 kg of K_2O ha^{-1} as polyhalite	8.21	20.05	7.14	3.53
T_{10}*-50 kg of K_2O ha^{-1} as polyhalite	7.82	19.04	6.75	3.45
$S.E_d$	0.08	0.15	0.08	0.02
C.D (0.05)	0.17	0.31	0.17	0.04

* RDF (N and P) common for all treatments

portion of areas sown on time, leading to higher yield potential compared with other fertilizers tried. Yi *et al.* (2021) found that applying potassium through polyhalite along with nitrogen and phosphorus enhanced fruit yield and showed better quality in pepper.. The potassium application through polyhalite significantly enhanced the yield attributes of blackgram than application of muriate of potash.

Grain yield and haulm yield (kg ha^{-1})

The yield of blackgram was significantly enhanced by application of graded doses of potassium applied through muriate of potash and polyhalite over control (K) and absolute control (Table 3). Using 37.5 kg K_2O ha^{-1}through polyhalite (T_9) produced maximum grain yields of 1439 kg ha^{-1} and haulm yields of 1876 kg ha^{-1}. Regardless, potassium applied through either muriate of potash or polyhalite at 37.5 kg K_2O ha^{-1} was significantly superior to potassium applied through either muriate of potash or polyhalite at 12.5, 25 and 50 kg K_2O ha^{-1}. Grain yield and haulm yield were lowest in absolute control (T_1). Through more balanced mineral nutrition of blackgram, application of potassium as polyhalite responded with significant increases in grain yield. It is because plants have an increasing need for potassium in their biochemistry and physiology, and that in at least 60 enzyme systems within them, potassium is essential for processes like photosynthesis, water relationships,

Table 3. Effect of different levels of muriate of potash and polyhalite on yield (kg ha^{-1}) of blackgram

Treatments	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1 - Absolute control	775	1205
T_2* - Control (-K)	923	1303
T_3* - 12.5 kg of K_2O ha^{-1} as MOP	1010	1376
T_4* -25 kg of K_2O ha^{-1} as MOP	1150	1532
T_5* - 37.5 kg of K_2O ha^{-1} as MOP	1381	1817
T_6* - 50 kg of K_2O ha^{-1} as MOP	1265	1695
T_7* - 12.5 kg of K_2O ha^{-1} as polyhalite	1086	1453
T_8* - 25 kg of K_2O ha^{-1} as polyhalite	1210	1611
T_9* - 37.5 kg of K_2O ha^{-1} as polyhalite	1439	1876
T_{10}*-50 kg of K_2O ha^{-1} as polyhalite	1325	1755
$S.E_d$	20.96	27.78
C.D (0.05)	44.37	58.8

* RDF (N and P) common for all treatments

protein synthesis, and photosynthesis. Increasing potassium doses up to 60 kg ha^{-1} significantly increased the grain yield and stover yield of pigeon pea and mustard crop reported by Tiwari *et al.* (2012). Garnett (2021) reported that replacing muriate of potash with polyhalite was a clear increase of tuber yield under high polyhalite rates and potential of polyhalite fertilizers to enhance crop performance and quality through more balanced mineral nutrition. In addition, Tien *et al.* (2021) found that application of polyhalite, in combination with muriate of potash, polyhalite significantly enhances crop performance and consequently leads to a substantial increase in total and marketable yields from 33 to 47 per cent and also indicates the advantage of polyhalite as a supplemental fertilizer contributing potassium as well as other essential macronutrients. In this way, the polyhalite performed significantly than muriate of potash and increased the yield of blackgram.

Conclusion

In the present study, the application of 37.5 kg K_2O ha^{-1} as polyhalite along with recommended doses of N and P resulted in significant increases in plant height, number of branches per plant, dry matter yield, leaf area index, pod length, pod number, 100 seed weight, seed yield, and haulm yield among various treatments. The present study indicated that compared to the usual fertilizer practices of local farmers, polyhalite treatments increased growth attributes, yield attributes, and yield of black gram in loamy sand soil. Thus, the potassium as polyhalite was beneficial in enhancing and sustaining blackgram growth and its yield.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Chandrasekhar, C.N. & Bangarusamy, U. (2003). Maximizing the yield of mung bean by foliar application of growth regulating chemicals and nutrients. *Madras Agric. J.*, 90(1-3), 142-145.
2. Chesnin, L. & Yien, C.R. (1951). Turbidimetric determination of available sulphates. *Soil Sci. Soc. Amer. Proc.,* 15*,* 149-151.
3. DES, Ministry of Agriculture & FW (DAC & FW), Govt. of India. (2021). https://agricoop.nic.in.
4. Garnett, S. (2021). Potential of Polyhalite Fertilizers to Enhance Potato Yield and Quality in the United Kingdom. *Int. Potash Inst. (e-Ifc)*, (63), 18-27.
5. Jackson, M.L. (1973) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 498.
6. Kemp, S.J., Smith, F.W., Wagner, D., Mounteney, I., Bell, C.P., Milne, C.J., Gowing, C.J.B. & Pottas, T.L. (2016). An improved approach to characterize potash-bearing evaporite deposits, evidenced in North Yorkshire, United Kingdom. *Econ. Geol.*, *111*(3), 719-742. https://doi.org/10.2113/econgeo.111.3.719
7. Kumar, D., Singh, R.P., Somasundaram, J., Simaiya, V. & Jamra, S. (2018). Effect of foliar application of nutrients on growth and development of blackgram (*Vigna mungo* (L.) *Hepper*) under rainfed Vertisols of Central India. *Int. J. Chem. Stud.*, 6(1), 609-613.
8. Navitha, D., Mahendran, P.P., Suresh, S., Beaulah, A. & Kannan, P. (2019). Growth and yield of tomato as influenced by potassium and secondary nutrients. *Int. J. Chem. Stud.*, 7(5), 683-688.
9. Nieves-Cordones, M., Shiblawi, A., Razzaq, F. & Sentenac, H. (2016). Roles and transport of sodium and potassium in plants. *The alkali metal ions: Their role for life*, 16, 291-324. https://doi.org/10.1007/978-3-319-21756-7_9
10. Pankaj, S.C. & Dewangan, P.K. (2017). Weed management in black gram (*Vigna mungo* L.) and residual effect of herbicides on succeeding mustard (*Brassica juncea* L.) crop. *Intl. J. Curr. Microbiol. Appl. Sci.*, *6*(11), 865-881. https://doi.org/10.20546/ijcmas.2017.611.101
11. Piper, C.S. 1966. Soil and Plant Analysis**.** *Hans Publishers*, Bombay.
12. Rosa, R.P., Pittelkow, F.K. & Vale, F. (2020). Evaluation of potassium and sulfur fertilizers for soybean in Brazil. *Int. Potash Inst. (e-ifc)*, (59), 3-9.
13. Stanford, D. & English. L. (1949). Use of flame photometer in rapid soil tests of K and Ca. *Agron. J.,* 4, 446-447.
14. Subbiah, B.V. & Asija, L.C. (1956). A rapid method of estimation of available nitrogen in soils. *Curr. Sci.,* 25**,** 258 -260.
15. Tien, T.M., Trang, T.T.T., Ha, P.T.N. & Thu, T.T.M. (2021). Effects of polyhalite application on yield and quality of cabbage grown on degraded soils in Northern Vietnam. *Int. Potash Inst. e-ifc,* (63), 3-10.
16. Tiwari, D.D., Pandey, S.B. & Dubey, M.K. (2012). Effect of potassium application on yield and quality characteristics of pigeon pea (*Cajanus cajan*) and mustard (*Brassica juncea* L. *Czern*) crops in central plain zone of Uttar Pradesh. *Int. Potash Inst.., e-ifj*, *31*, 16-20.
17. Walkley, A. & Black, C.A. (1934). An examination of Deglgreff method for determining soil organic matter and proposed modification of chromic and titration method. *Soil Sci.,* 37, 29-38.
18. Watanabe, I. & Olsen, S.R. (1965). Test of ascorbic acid methods for determining phosphorus in water and NaHCO_3 extracts from soil. *Soil Sci. Soc. Am. Proc.,* 29, 677-678.
19. 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 J. Plant Sci.*, *64*(3-4), 145-157.
20. 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. *Int. Potash Inst., (e-ifc)*, (65), 12-23.
21. Zhao, N., Guo, H., Suo, J., Lei, Y., Li, G., Imas, P. & Magen. (2020). Impact of alternative polyhalite fertilizers on 'Xu Xiang' Kiwifruit yield and quality in Shaanxi Province, China. *Int. Potash Inst., (e-ifc)*, (62),13-2.