Plant Archives Vol. 15 No. 1, 2015 pp. 347-351 ***ISSN 0972-5210***

EFFECT OF POTASSIUM AND SULPHUR LEVELS ON SOIL FERTILITY STATUS AFTER HARVEST OF MUSTARD

P. G. Gajghane, S. S. Toncher*[1] and M. M. Raut[2]

Department of Soil Science, College of Agriculture, Nagpur, Dr. P. D. K. V., Akola (Maharashtra), India.
[1]Department of Agronomy, Post Graduate Institute, Dr. P.D.K.V., Akola – 444 001 (Maharashtra), India.
[2]Department of S.S.A.C., College of Agriculture, Nagpur, Dr. P. D. K. V., Akola (Maharashtra), India.

Abstract

The field experiment was conducted to study the "Effect of potassium and sulphur levels on yield, nutrient uptake and quality of mustard" at College of Agriculture farm, Nagpur, during *rabi* season of 2012-13. Sixteen treatment combinations were studied in FRBD with three replications, which comprises four levels of potassium (0, 15, 30 and 45 kg ha^{-1}) and four levels of sulphur (0, 10, 20 and 30 kg ha^{-1}). Therefore, significantly increases in organic carbon, calcium carbonate and improvement in the available nitrogen (317.23 kg ha^{-1}), phosphorus (18.87 kg ha^{-1}), potassium (407.03 kg ha^{-1}) and sulphur (9.72 kg ha^{-1}) status after harvest of mustard by the addition of doses fertilizers, respectively.

Key words : Mustard, potassium, sulphur, soil fertility.

Introduction

Mustard is an important *rabi* oilseed crop of India, widely grown on large area. It occupies prominent place, next in importance to groundnut in area and production. It contains about 37 to 49 per cent oil in the seed. Low cost of production and high yield potentials, hold promise for its large scale cultivation in the country (Singh, 1998).

In India, the area under mustard was 6.69 million hectares, producing about 6.60 million tonnes of seed with an average productivity of 1145 kg ha^{-1} (Anonymous, 2011a). Area under mustard cultivation in Maharashtra was 12000 hectares with production of 4000 tonnes seed with an average productivity of 308 kg ha^{-1} (Anonymous, 2011b). In Vidarbha area under cultivation was 865 hectares with a production of 330 tonnes and with an average productivity of 380 kg ha^{-1}. The districts in which mustard grown are Chandrapur, Gondia, Bhandara, Gadchiroli, Nagpur and Wardha (Anonymous, 2011b).

The important mustard growing countries of the world are India, China, Canada, France, Poland and Pakistan. Major states producing mustard are Rajasthan, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, West Bengal and Gujarat.

Potassium is one of the three major essential nutrient elements required by plants. It is involved in nearly all processes needed to sustain the plant life. Potassium is known to help crop to perform better under water stress through the regulation of the rate at which plant stomata open and close. It is also known for its role to provide lodging resistance and insect/disease resistance to plants. Since, potassium is involved in many metabolic pathways that affect crop quality, it is often called as "the quality element" (Rao and Srinivasarao, 1996). Potassium is one of the major nutrients in soil, amongst the mineral cations required by plant. The earth crust contains 2.4% potassium. It is largely present in complex silicate components; some potassium is associated with organic matter and clay fraction of soil. The potassium content in the soil varies from 0.1% to 3.0% or even more.

Sulphur is now recognized as the 4th major plant nutrient after N, P and K. Besides the major nutrient, sulphur plays important role in Indian mustard. Sulphur is needed for development of cell and increases cold resistance and drought hardness of plant. Sulphur is also enhancing nitrogen fixation in some oilseed like groundnut and soybean, since it is an active constituent of nitrogenous enzyme, which is vital for N_2 fixation.

In Maharashtra, the productivity of mustard is very low. The declined soil fertility is the main cause of low productivity of the cultivated lands. So far the emphasis has been to supplement the soil with the major nutrients

***Author for correspondence :** E-mail : sandiptonchar@gmail.com

viz., N, P, K and the crop requirements for secondary (Ca, Mg and S) and micronutrients (Zn, Fe, Cu and Mn) could be met from the soil reserve. According to soil test findings use of high analysis fertilizers, limited recycling of plant residues and gap between the removal and supplementation of secondary and micro-nutrients have resulted in widespread multiple nutrient deficiencies, especially of N, P, K, S and Zn along with other nutrients (Fe and Cu).

In recent years, potassium and sulphur deficiency has been aggravated in the soil due to continuous crop removal and use of potassium and sulphur analysis NPK fertilizers. Leaching and erosion losses also contribute to sulphur deficiencies.

For oilseeds, potassium and sulphur are most vital nutrients for the growth and development of mustard crop. Besides N and P, the use of K has been reported to influence the productivity of seed yield and seed oil contents (Ghosh *et al*., 1995). Potassium nutrition is associated with grain quality, including protein content. Potassium stimulates the transport of nitrogenous compounds to developing fruits and thereby increase seed yield.

Sulphur is a master nutrient of oilseed production. It is essential for protein production because, it is a constituent of three main amino acid *viz.*, cystine, cysteine and methionine. It activates certain enzyme systems and is a component of some vitamin (vitamin A). Sulphur is found in mustard oil glycosides, which impart characteristic odours and flavours to such plants as mustard and also involved in many physiological functions like amino acid synthesis in addition to productivity. Application of K and S is also important in increasing the efficiency of other nutrients.

Materials and Methods

Nagpur is situated at 21^{o} 10' North latitude and 79^{o} 10' East latitude at the elevation of 321.26 m above sea level and lies under sub-tropical zone. Nagpur is characterized by hot and dry summer and fairly cold winter. This area shows wide diurnal fluctuation in temperature. The maximum and minimum temperature ranged from 29.6^{0}C to 34.1^{0}C and 9.9^{0}C to 19.4^{0}C, respectively, whereas the relative humidity varied from 20 to 72 per cent during the crop growth period, mean annual precipitation is about 938.4 mm.

The field experiment was conducted to study the "Effect of potassium and sulphur levels on yield, nutrient uptake and quality of mustard" at College of Agriculture Farm, Nagpur, during *rabi* season of 2012-13. Sixteen treatment combinations were studied in FRBD with three replications, which comprises four levels of potassium (0, 15, 30 and 45 kg ha^{-1}) and four levels of sulphur (0, 10, 20 and 30 kg ha^{-1}). The experimental site was medium black, moderately alkaline in reaction, clayey in texture, medium in organic carbon (5.29 g ka^{-1}), low in available N (174.25 kg ha^{-1}), medium in available P (15.78 kg ha^{-1}), high in available K (340 kg ha^{-1}) and low in available S.

The soil sample were collected from 15-30 cm depth of soil profile with the help of screw auger before sowing of mustard to study the impact of various fertility treatments on soil properties. It was air dried in shade, grinded and analyzed for determination of physical and chemical properties of soil. Treatment wise soil samples 15-30 cm depth from each plot were collected after harvesting of crop. The samples were air dried, grinded and analyzed for estimation of available nitrogen, phosphorous and potassium. Balance sheet of N, P_2O_5 and K_2O was worked by considering initial fertility status and final balance of nutrients in the soil after completion of experimentation.

The soil samples were analyzed for available nitrogen by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus (Olsen *et al*., 1954) and available potassium neutral N ammonium acetate extract using flame photometer (Hanway and Heidel, 1952).

Grain and straw samples were digested with diacid mixture of HNO_3 and $HClO_4$ in 9:4 ratio. Total phosphorus in the extract was estimated by reacting the extract with vanadomolybdate forming yellow colour complex in HNO_3 medium and solution was read at colorimeter using blue filter. The extract was diluted to appropriate concentration and was directly atomized to the flame photometer at 548 nm wavelength. Total nitrogen in plant samples was determined by Kjeldahl method (Jackson, 1967).

Results and Discussion

Use of fertilizers and Manures is king pin of strategy for achieving the queen objectives of enhanced productivity and assure sustainability. In this strategy one aspect which has been neglected in past, is the balanced use of fertilizers. It is needless to emphasize that potassium is third essential plant nutrient and sulphur which is the fourth essential plant nutrient and exceeds. Therefore, the individual and combined effect of potassium and sulphur was taken up with the objective of enhancing the productivity of mustard with assured sustainability.

Soil reaction (pH)

The data presented in table 1 revealed that the application of potassium significantly decreased the pH of soil after harvest of mustard. The highest value of pH was recorded in the control (8.01). It was observed that as increasing the levels of potassium there was a significant decrease the pH of the soil, however the lowest value of pH was recorded with the application of 45 kg potassium ha^{-1} (7.78) followed by 30 kg potassium ha^{-1} (7.81).

The effect of different levels of sulphur on pH of soil after harvest of mustard was found to be statistically non-significant. The interaction effect of potassium and sulphur on pH of soil was found to be non-significant.

There was consistent decrease in pH of soil with increased in applied level of potassium. The application of sulphur enhances the availability of soluble calcium directly and indirectly through dissolution of native $CaCO_3$. The Ca thus release that absorb positive from exchangeable complex and the removal of soluble sodium with other salts (CO_3 + HCO_3) through leaching, reduce the pH of soil. Similar findings also reported by Sagare *et al.* (2001) the decrease in pH was found mainly due to replacement of Na^+ with Ca^{++} added through sulphur and also reported reduction in pH of post harvest soil due to application of sulphur Yadav and Chippa (2007).

Electrical conductivity

The data related to electrical conductivity after harvest of mustard crop as affected by different level of potassium and sulphur is presented in table 1. The highest EC after harvest of mustard was recorded by treatment K_0 (0.36 dSm^{-1}) followed by treatment K_{15} (0.38 dSm^{-1}). The lowest EC was recorded with the application of 45 kg potassium ha^{-1} (0.20 dSm^{-1}).

The effect of different levels of sulphur on electrical conductivity of soil after harvest of mustard was found to be statistically significant. The highest EC after harvest of mustard was recorded by treatment S_0 (0.354 dSm^{-1}), followed by treatment S_0 (0.30 dSm^{-1}). The lowest Ec was recorded with the application of 30 kg sulphur ha^{-1} (0.27 dSm^{-1}).

The interaction effect of potassium and sulphur on electrical conductivity of soil was found to be non-significant.

Organic carbon content

The data with respect to organic carbon in soil after harvest of mustard is presented in table 1. The organic carbon content in soil regulates the nutrient availability to crops. Hence, its availability in soil after harvest of mustard crop was observed. The data exhibited statistically significant difference. The highest organic carbon content was recorded in treatment K_{45} (6.14 g kg^{-1}) followed by treatment K_{30} (5.98 g kg^{-1}). However, lowest organic carbon content was recorded in treatment K_0 (5.3 g kg^{-1}). Similar results were also reported by Meena *et al.* (2006) who reported that organic carbon content in soil increased significantly over control due to addition of S, Zn and Fe, there was an increase in O.C.% from 0.27 to 0.29% due to application of S at 20 kg ha^{-1}.

The organic carbon content in soil after harvest was found non-significant due to the application of sulphur. The interaction effect of potassium and sulphur for organic carbon content in soil after harvest was found to be non-significant.

Calcium carbonate content

The data with respect to calcium carbonate in soil after harvest of mustard is presented in table 16. Hence its availability in soil after harvest of mustard crop was observed. The data exhibited statistically significant difference. The highest calcium carbonate content was recorded in treatment K_{45} (5.96%) followed by treatment K_{30} (5.86%). However, lowest organic carbon content was recorded in treatment K_0 (5.28%). The calcium carbonate content in soil after harvest was found non-significant due to the application of sulphur. The interaction effect of potassium and sulphur for calcium carbonate content in soil after harvest was found to be non-significant Abo- Rady *et al.* (1988) studied that the contents of $CaCO_3$ and pH values decreased with an increase in sulphur level.

Availability of nutrients in soil after harvest of mustard

Fertilizer application provides nutrients to crops, but 100% of the nutrients could not recover, it helps to build up residual fertility of soil. Nutrient interaction in soil renders some nutrients unavailable or decreases their availability. This is due to formation of insoluble compounds or dislocation of cations or anions from exchange sites. The results regarding the effect of treatments on residual fertility are interpreted as follows.

The data pertaining to available N, P, K and S after harvest of mustard as influenced by different levels of potassium are presented in table 1. From the data, it revealed that the available nitrogen after harvest of mustard was found significant. With the increased in the rate of potassium from 0 to 45 kg ha^{-1}, there was significant increased in available N, P, K and S. The maximum available N (317.23 kg ha^{-1}) was recorded with the application of 45 kg potassium ha^{-1}, followed by the

Table 1 : Effect of potassium and sulphur on pH, EC (dSm^{-1}), organic carbon ($g\ kg^{-1}$) and calcium carbonate content (%) of soil after harvest of mustard.

Treatments	pH	EC (dSm^{-1})	Organic carbon ($g\ kg^{-1}$)	Calcium carbonate (%)
Levels of Potassium (kg ha^{-1})				
K_0	8.01	0.36	5.31	5.28
K_{15}	7.84	0.38	5.79	5.76
K_{30}	7.81	0.25	5.98	5.86
K_{45}	7.78	0.20	6.14	5.96
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em.±	0.05	0.35	0.15	0.17
CD at 5%	0.16	1.05	0.45	0.50
Levels of Sulphur (kg ha^{-1})				
S_0	7.96	0.35	5.40	5.37
S_{10}	7.89	0.30	5.91	5.75
S_{20}	7.84	0.25	5.92	5.76
S_{30}	7.75	0.27	5.97	5.97
'F' test	N.S.	Sig.	N.S.	N.S.
S.Em.±	0.05	0.35	0.15	0.17
CD at 5%	0.16	1.05	0.45	0.50
Interaction (Potassium × Sulphur)				
'F' test	N.S.	N.S.	N.S.	N.S.
S.Em.±	0.11	0.04	0.31	0.35
CD at 5%	-	-	-	-

treatment 30 kg potassium ha^{-1} (314.69 kg ha^{-1}) and the lowest available N was recorded in control (308.38 kg ha^{-1}). With the increasing level of potassium, there was significant increased in available P. The highest available P was recorded (18.87 kg ha^{-1}) with the application of 45 kg potassium ha^{-1}, which was found at par with the application of 30 kg potassium ha^{-1} (18.73 kg ha^{-1}). The lowest value of available P was recorded in control (16.54 kg ha^{-1}). whereas, available K and S varied from 402.82 to 407.03 kg ha^{-1} and 6.89 to 9.72 mg kg^{-1}, respectively with different levels of potassium.

The significant increase in available nutrient status of soil due to application of potassium may be attributed to the fact that addition of potassium brought about remarkable improvement in the physico-chemical properties of soil. The increased mineralization of native as well as applied nutrients brought about a considerable increase in both macro (N, P, K and S) and micronutrients particularly Fe in the soil. Basumatri *et al.* (2010) also revealed that the N, P and K were in medium range and lower amount of sulphur in soil.

The results from the table 2 revealed that available N, P, K and S was increased significantly, while available

Table 2 : Effect of potassium and sulphur on fertility status of soil after harvest of mustard.

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available S (mg kg^{-1})
Levels of Potassium (kg ha^{-1})				
K_0	308.38	16.54	402.82	6.89
K_{15}	310.42	17.45	405.45	8.54
K_{30}	314.69	18.73	406.44	9.14
K_{45}	317.23	18.87	407.03	9.72
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em.±	1.03	0.20	0.71	0.30
CD at 5%	2.97	0.60	2.06	0.87
Levels of Sulphur (kg ha^{-1})				
S_0	309.84	17.30	402.54	7.89
S_{10}	313.52	17.79	404.12	8.4
S_{20}	314.81	18.09	408.06	9.21
S_{30}	312.53	18.40	407.01	8.75
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em.±	1.03	0.20	0.71	0.30
CD at 5%	2.97	0.60	2.06	0.87
Interaction (Potassium x Sulphur)				
'F' test	N.S.	N.S.	N.S.	N.S.
S.Em.±	2.06	0.41	1.43	0.60
CD at 5%	-	-	-	-

P was increase with higher levels of sulphur, the application of sulphur significantly increased available N in soil after harvest. The higher available N (314.81 kg ha^{-1}) was recorded with the application of 20 kg sulphur ha^{-1}, which was found at par with application of 30 kg sulphur ha^{-1} (312.53 kg ha^{-1}) and the lowest value of available N was recorded in control (309.84 kg ha^{-1}).

It is evident from the data in table 2 that with the increasing rates of sulphur fertilization from 0 to 30 kg sulphur ha^{-1}, there was increased in available phosphorus (18.40 kg ha^{-1}). Addition of 20 kg sulphur ha^{-1} resulted in significant decreased in available phosphorus (18.09 kg ha^{-1}). It may be due to antagonistic effect between sulphur and phosphorus.

The interaction effect between potassium and sulphur in respect of phosphorus was found to be non-significant. The results revealed that application of sulphur significantly increased the availability of K and S in soil after harvest. The highest available K and S were recorded with the application of 30 kg sulphur ha^{-1} (408.06 kg ha^{-1} and 9.21 mg kg^{-1}, respectively). However, the lowest available K and S were recorded in control (402.54 kg ha^{-1} and 7.89 mg kg^{-1}, respectively).

References

Abo-Rady, M. D. K., O. Duheash, M. Khalil and A. M. Turjopman (1988). Effect of elemental sulphur on some properties of calcareous soils and growth of date palm seedlings. *Arid Land Research and Management*, **2(2)** : 121–130.

Anonymous (2011a). Ministry of Agriculture, Govt. of India.

Anonymous (2011b). Joint director of Agri., Nagpur Division, Nagpur.

Basumatari, A., K. N. Das and B. Borkotoki (2010). Interrelationships of sulphur with soil properties and its availability index in some rapeseed-growing inceptisols of Assam. *J. of the Indian Society of Soil Science*, **58(4)** : 394-402.

Singh, Chiddha (1998). Importance of mustard in modern techniques of raising field crops. Oxford and IBH Publishing Co., Bombay, pp. 301.

Ghosh, D. C., P. K. Panda and P. M. Sahoo (1995). Response of rainfed rapeseed (*Brassica campestris* L.) to N, P, K. *Indian J. Agric. Res*., **29(1)** : 5-9.

Hanway, J. J. and H. Heidal (1952). Soil analysis, as used in lowa State. College of Soil Testing Laboratory, lowa. *Agriculture*, **57** : 1-31.

Jackson, M. L. (1967). *Soil chemical analysis*, Prentice Hall of India Private Limited, New Delhi.

Meena, M. C., K. P. Patel and D. D. Rathod (2006). Effect of zinc, iron and sulphur on mustard in loamy sand soil. *Indian J. Fertilizers*, **2(5)** : 55–58.

Olsen, S. R., C. V. Cole, F. S. Watanabe and L. A. Dean (1954). Estimation of available P in soils by extraction with sodium bicarbonate. Circular of the United States Department of Agriculture 939, US Government Printing Office, Washington D.C.

Subbiah, B. V. and G. L. Asija (1956). A rapid procedure for determination of available nitrogen in soil. *Current Sci*., **25** : 256-260.

Subba Rao, A. and Ch. Srinivasrao (1996). IPI Research Topics No. 20, International Potash Institute, Basel, Switzerland. P. 1-57.

Yadav, K. K. and B. R. Chhipa (2007). Effect of FYM, gypsum and iron pyrites on fertility status of soil and yield of wheat irrigated with high RSC water. *J. Indian Soc. Soil Sci*., **55(3)** : 324-329.