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Effect of phosphorus and sulphur and their interaction on mustard crop

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ABSTRACT

Oilseed Brassicas, rapeseed mustard accounting for over 13.2 per cent of the world's edible oil supply are third most important edible oil source after soyabean and palm. In India, it is the major oil crop rank second acreage with 6.23 million ha, superseded by the groundnut only. Phosphorus is an essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance, and of ribonucleic acid (RNA), which direct protein synthesis in both plants and animals. Sulphur is the 13th most abundant element in the earth's crust, an essential secondary plant nutrient, is required by plant and animals in approximately the same amount as phosphorus. In Brassicas, which are more susceptible to S-deficiency as it enhance oil quantity and quality both. In the past, farmers were using S-containing fertilizers *viz.*, ammonium sulphate and SSP but recently they have started using high N and P fertilizers which are S-free *viz.*, urea, DAP, and triple super phosphate. Therefore, the present study was taken up to find out the optimum dose and source of Sulphur fertilizer for mustard crop grown on an alluvial soil for optimum mustard oil production. In the study it was found that sulphur significantly responsible for oil content of mustard and when applied with phosphorus at 30 kg/ha, gives best response.

Key words : Alluvial soil, Brassicas, DNA, Interaction, Phosphrus, RNA, Sulphur

INTRODUCTION

Mustard is an important *Rabi* oilseed crop of India. It occupies about 24.70 per cent of area and 48.28 per cent of production of the total oilseed production in India. Its area, production and productivity in the country is 5.43 M. ha., 6.41 M.tonnes and 1159 kg/ha, respectively. In Rajasthan state the total area under mustard cultivation is 2.84 M.ha with the estimated production of 3.5 M. tonnes and average productivity of mustard in the state is 1234 kg/ha. So far as concerned with the Jhunjhunu district of Rajasthan , total area under mustard cultivation is 78.0 thousand hectares with the productivity of 1308 kg/ha.

Oilseed Brassicas, rapeseed mustard accounting for over 13.2 per cent of the world's edible oil supply are third most important edible oil source after soyabean and palm. In India, Brassicas rank second acreage with 6.23 million ha, superseded by the groundnut only. Because of their ability to germinate and grow at low temperature, the oil seed Brassicas can be grown in the cooler agricultural regions and at higher elevations, as well as winter crops in the temperate zones. The Brassicas have about 40 per cent oil on a dry weight basis. The meal contains 38-44 per cent high quality protein. In India three ecotypes of Brassicas are grown substantially. The production of rapeseed and mustard in India is around 1.62 million tonnes which account for about 18 per cent of the total oilseed production of the country. The oil obtained from the different types show slight variation in percentage of oil. The oil content varies from 37-49 per cent. The seed and oil are used as condiment in the preparation of pickles and for flavouring curries and vegetables. The oil is utilized for human consumption throughout northern India in cooking and frying purpose. It is also used in the preparation of hair oil and medicines. It is used in soap making, in mixtures with mineral oils for lubrication. Rapeseed oil is used in the manufacture of greases. The oil cakes is used as a cattle feed and manure. Green stems and leaves are a good source of green fodder for cattle. The leaves of young plant are used as green vegetable as they supply enough Sulphur and minerals in the diet. In the tanning industry, mustard oils is used for softening leather (Singh, 2001).

Neither plants nor animals can grow without phosphorus. It is an essential component of the organic compound often called the *energy currency* of the living cell: adenosine tri-phosphate (ATP). Synthesized through both respiration and photosynthesis, ATP contains a high-energy phosphate group that drives most energy requiring biochemical processes. For example, the uptake of nutrients and their transport within the plant, as well as their assimilation in to different biomolecules, are energy-using plant processes that require ATP. Phosphorus is an essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance, and of ribonucleic acid (RNA), which direct protein synthesis in both plants and animals.

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Phospholipids, which play critical role in cellular membranes, are another class of universally important Phosphorus containing compounds. For most plant species, the total phosphorus content of healthy leaf tissue is not high, usually comprising only 0.2 and 0.4 per cent of the dry matter (Brady, 2004). Phosphorus does not occur as abundantly in soil as N and K. Total concentration in surface soil varies between about 0.02 and 0.10 per cent Unfortunately, the quantity of total P in soils has little or no relationship to the availability of P to plants. Phosphorus is absorbed by plants largely as orthophosphate ions ($H_2PO_4^-$ and HPO_4^{2-}), which are present in the soil solution. Some low molecular weight, soluble organic P compound exist in soil solution and may be observed, but generally they are of minor importance. The average soil solution P concentration is about 0.05 ppm and varies widely among soils. The solution P concentration required by most plant varies from 0.003 to 0.3 ppm and depends on the crop species and level of production.

In Phosphorus deficient plant, the growth is retarded and shoot/root dry matter ratio usually decreases. In cereal crops, tillering is affected. In case of fruit trees, the fruit and seed formation is drastically affected by P deficiency. All these disorder not only give low yields but also poor quality of products. Usually the symptoms of P deficiency appear in the older leaves which are darkish green colour. The stem of many plants suffering from P deficiency are characterized by a radish colouration originating from an increased production of anthocyanins. The leaves of P deficient fruit trees are frequently finged with brownish colour. The P contents in the P deficient plants are usually low with about 0.1 per cent P or less in the dry matter and in cereals and herbage about 0.3 to 0.4% during the vegetative growth stage. Under conditions of P deficiency, Phosphorus is withdrawn form order tissue and translocated to meristematic tissue, where metabolism is more rapid. The requirement of phosphorus for the optimum growth is in the range of 0.3 to 0.5 per cent (dry weight basis) during the vegetative stage of the plant growth. The possibility of phosphorus toxicity increases at a concentration more than 1 per cent in dry matter of the plant. In plants suffering from Phosphorus deficiency, leaf expansion, leaf area and number of leaves are reduced. Very oftenly, the chlorophyll content is even increased under Phosphorus deficiency, and the leaves have a dark green colour as cell and expansion of leaves are more reduced than chloroplast and chlorophyll formation. However, the photosynthetic efficiency per unit of chlorophyll is much lower in Phosphorus deficient plant, (Das, 2004).

Sulphur is the 13th most abundant element in the earth's crust, averaging between 0.06-0.10 per cent and an essential secondary plant nutrient, is required by plant and animals in approximately the same amount as phosphorus. However, recently Sulphur is gaining importance for crop production in the balanced fertilization programme. Sulphur, like phosphorus, potassium and calcium is of terrestrial origin, resulting from the decomposition of rocks. Because of its volatile nature, a large amount of Sulphur has become dispersed in the atmosphere. Such atmospheric fraction contributes significantly to the plant growth and nutrition (Das, 2004). Sulphur is mostly present as sulphides, sulphates and organic fraction - associated with N and C. The Primary source of Sulphur is sulphide bearing plutonic rocks which on weathering these sulphides convert into sulphates, some of which dissolves, precipitate and reduce to even elemental Sulphur depending upon the conditions. Besides, atmosphere is recognized as an another source of Sulphur in soil where Sulphur dioxide is produced and subsequently, brought down by rain. Fertilizer, organic manures and irrigation water etc. are also important source of Sulphur which contribute considerable amount of Sulphur to the soil (Das, 2004). Sulphur is present in the soil in both organic and inorganic forms, although nearly 90 per cent of the total Sulphur in on most noncalcareous surface soil exists in organic forms. The inorganic form are solution SO_4^{2J}, Adsorbed SO_4^{2J}, insoluble SO_4^{2J}, and reduced inorganic sulphur compounds. Solution plust adsorbed SO_4^{2J}, represent the readily available fraction of Sulphure utilized by plants (Tisdale, 2002). Sulphur is absorbed by plants as sulphate ions SO_4^{2J}. There are some reports that Sulphur is absorbed by the foliage as SO_2. Like P and Mg, the concentration of S in healthy plants ranges from 0.1 to 0.4 per cent. In view of large field scale occurrences of deficiencies in India, Sulphur has been described as the fourth major nutrients after N, P and K.

Depending upon the plants having less than 0.1 to 0.2 per cent S- content suffer from Sulphur deficiency. Crop plants having N: S ratio more than 16: 1 also can be suspected to be deficient in Sulphur. Sulphur deficiencies first appear on the younger growths as it is immobile in the plants. The fading of the normal green colour of the young leaves, followed by chlorosis is the most common deficiency symptoms. In Brassicas, which are more susceptible to S-deficiency, the lamina is restricted, leaves show cupping owing to the curling of the leaf margins and arresting of the growing points. The older leaves become puckered with inward raised areas between the veins. The older foliage develops orange or radish tints and may shed prematurely (Goswami and Rattan, 2004).

Sulphur has long been recognized as indispensable for much reaction in living cell. In addition to its vital role in plant and animal nutrition, Sulphur is also responsible for several type of air, water and soil pollution and is therefore of increasing environmental interest. The environmental problems associated with Sulphur include acid precipitation, certain type of forest decline, acid mine drainage, acid sulphate soil and even some toxic effects in drinking water used by humans and livestock. S has many important functions in plants growth and metabolism. It is required for synthesis of the Sulphur containing amino-acids, cystine, cysteine and methionine, whcih are essential components of protein. Approximately 90 per cent of the S in plants is found in these amino acids. One of the main functions of S in proteins is the formation of disulfide bonds between polypeptide chain. This bridging is achieved through the reaction of two cysteine molecules, forming cystine. Linking of two cysteine units within a protein by a disulfide bond (-S-S-) will cause the protein to fold. Sulphur is needed for the synthesis of other metabolites, including coenzyme-A, biotin, thiamin or vitamin B_1 and glutathione. Sulphur is also a component of other S-containing substances, including S-adenosylmethionine, formylmethionine, lipoic acid and sulpholipid. Although not a constituent, Sulphur is required for the synthesis of chlorophyll. Sulphur is a vital part of ferredoxins, a type of nonheme Fe-S protein occuring in the chloroplasts. Ferredoxin participates in oxido-reduction processes by transferring electrons and has a significant role in nitrate reduction, sulphate reduction, the assimilation of N_2 by root nodule bacteria and free-living N-fixing soil bacteria.

Sulphur occurs in volatile compound responsible for the characteristic taste and smell of plants in the mustard and onion families. S enhances oil formation in crops such as flax, mustard and soyabean (Tisadle, 2002). Dependence of oilseed crops on Sulphur nutrition from both yield and quality point of view is well known. Mustard is one of the major source of edible oil for peoples of northern states of our country. In the state of Madhya Pradesh, soil of northern districts are mostly alkaline and are deficient in Sulphur and yield of mustard is low.

It has been already proved the role of S for oilseed crops as there enzymatic role in oil formation. In the past, farmers were using S-containing fertilizers *viz.*, ammonium sulphate and SSP but recently they have started using high N and P analysis S-free fertilizers *viz.*, urea, DAP, and triple super phosphate. Therefore, the present study was taken up to find out the optimum dose and source of Sulphur fertilizer for mustard crop grown on an alluvial soil for optimum mustard oil production.

MATERIALS AND METHODS

Field experiment was conducted to study the effect of different levels of phosphorus and sulphur on growth and yield of mustard (*Brassica campestris* L.) at the experimental farm of Sheila Dhar Institute of Soil Science situated in front of the Institute at Lajpat Rai Road, Allahabad. The climate of the district is semi *arid* with hot summer and cold winter. The average rainfall here is about 82.1 cm and mean annual temperature varies from 32.4°C to 45.6°C. The humidity is about 65 per cent.

The physico-chemical properties of experimental field were determined in composite soil sample taken before sowing. The values are given below in the Table A.

Table A : Physico-chemical properties of experimental field

Sr. No.	Soil properties	Value
1.	pH	7.16
2.	EC (dS m^{-1} at 25 °C	0.28
3.	CEC {C mol kg^{-1} (p+) kg^{-1}}	20.90
4.	Organic matter (in %)	0.91
5.	Total nitrogen (in %)	0.093
6.	Available nitrogen (in %)	0.003
7.	Total phosphorus (in %)	0.089
8.	Available phosphorus (%)	0.029
9.	Available potassium (%)	0.006
10.	Available sulphur (%)	0.019
11.	Sand (%)	55.00
12.	Silt (%)	25.00
13.	Clay (%)	20.00
14.	Textural class	Sandy clay loam

The experiment was laid out in micro plot of (1×1 m^2) consisting 9 treatments with three replication. phosphorus and sulphur were supplied through diammonium phosphate (48% P_2O_5) and ammonium sulphate (24.2% S), respectively. The phosphorus is applied in amount of 0, 40 and 60 kg/ha and sulphur is applied in 0, 20 and 30 kg/ha, respectively.

Land preparation was started before 20 days of sowing and layout was carefully done as per need of experiment. Phosphorus was supplied through DAP in calculated amounton the basis of phosphorus pentaoxide (P_2O_5-46%) and applied before 2 days of sowing of mustard crop at field capacity. After 2 days, it was mixed with the soil. Sulphur was supplied through ammonium sulphate. The required amount of ammonium sulphate was calculated on the basis of their sulphur (24.2%) and applied at the time to sowing according to plan of layout in experimental period. The nitrogen and potash is applied in recommended amount in all plot.

The mustard variety PT-303 was sown in recommended manner. Thinning and weeding carried out in two phases. Two irrigations are given to mustard crop. First irrigation is applied after 30- days of sowing and second irrigation is given at the flowering stage, after 60-65 days of sowing. To check the damage by mustard aphids Indosulfan 35 E.C. spraying has been done at the rate of 1.25 Lit/ha.

The particular about experiment is given in following Table B.

Table B : Experimental details

Sr. No.	Particulars	Details
1.	Variety	PT-303
2.	Germination %	85%
3.	Physical purity	80%
4.	Genetical purity	85%
5.	Seed rate	85%
6.	Test weight	4.2 gm
7.	Planting distance	30×15 cm
8.	Depth of seed showing	3.5 cm
9.	Season of seed sowing	Winter
10.	Crop length (in days)	90-100
11.	No. of treatment	9
12.	No. of replication	3
13.	Total no. of plots	27
14.	Design	RBD

The crop was harvested after 100 days of sowing, when it becomes mature as judged by visual observations. The production of net plot is weighted individually and recorded after threshing. Threshing is done by wooden sticks and seed weight. Plant samples were taken randomly from each treatment at maturity stage. These plant samples were oven dried, and weight of plants were taken for the analysis of growth parameters and biochemical analysis. Plant height, number of primary branches, number of siliqua/plant, number of seed/siliqua seed yield recorded at pre fixed time and interval. For oil content estimation seed samples were kept in the oven at 70°C for the removal of moisture. After removal of the moisture the seed was grounded in a pestle-mortar for extraction of oil. The conventional *soxthlel m*ethod was used for estimation of oil. However the effect of phosphorus and sulphur integration on soil fertility and mobility in mustard plant was also studied but this is not concerned in this paper.

RESULTS AND DISCUSSION

The observation recorded on various growth, yield and yield contributing characters during entire course of investigation were subjected to various statistical analysis. The result obtained are summarized and presented below:

The above presented Fig. 1 that both phosphorus and sulphur individually were responsible to increase the height of the plants, after 30 days of sowing. Application of 60 kg/ha phosphorus individually increased the height of mustard plants about 7.47 per cent at 30 DAS, 3.18 per cent at 60 DAS and 3.24 per cent at harvesting over the control. On the other hand application of 30 kg/ha sulphur individually increased the height of the plants about 3.85 per cent at 30 DAS, 2.20 per cent at 60 DAS and 1.002 per cent at maturity over the control. The combined effect of phosphorus and sulphur @ 60 kg P/ha and 30 kg S/ha gave the maximum increase about 10.91 per cent in plant at 30 DAS, 7.19 per cent at 60 DAS and 8.94 per cent at maturity over the control. Therefore, it can be concluded that the interaction between phosphorus and sulphur found synergetic on plant height at 30 DAS, however P×S interaction were non-significant on the height of the mustard plants at 60 DAS. It was observed that effect of Phosphorus was higher in magnitude than the effect of Sulphur on plant height during intire plant growth period. The application of Phosphorus and Sulphur @ 60 kg /ha and @ 30 kg/ha were found beneficial for early well developed and matured growth of mustard plants.

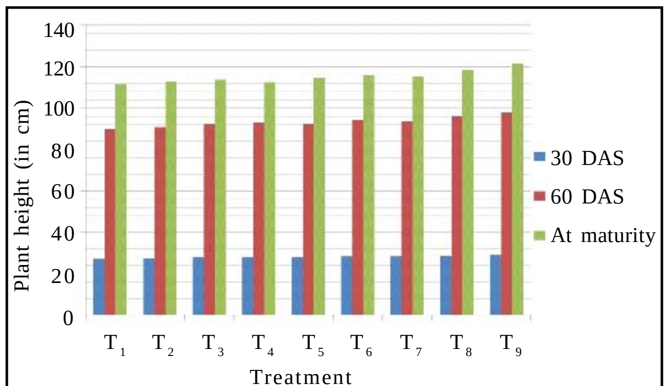

Fig. 1 : Effect of P×S interaction on plant height

The data graphically presented in Fig. 2 clearly shows that the phosphorus and sulphur were found significant, but P×S interaction were non-significant on the number of primary branches of mustard plants of 50 DAS. Application of 60 kg/ha phosphorus individually increased the number of primary branches of mustard pants about 21.98 per cent at 50 DAS and 16 per cent at maturity over the control. On the other hand application of 30 kg / ha sulphur individually increased the number of the primary branches of the plants about 19.85 per cent at 50

DAS and 10.62 per cent at maturity over the control. The combined effect of phosphorus and sulphur @ of 60 kg P/ha and 30 kg S/ha produced the maximum increase about 41.84 per cent in the number of primary branches of the plants at 50 DAS and 29 per cent at maturity over the control plot. Therefore, it was concluded that the effect of phosphorus was higher in magnitude than the effect of sulphur on the number of primary branches after 50 DAS and at maturity. It was also observed that sulphur and P×S interaction were non-significant but phosphorus was significant on the number of primary branches of mustard plants at harvesting stage.

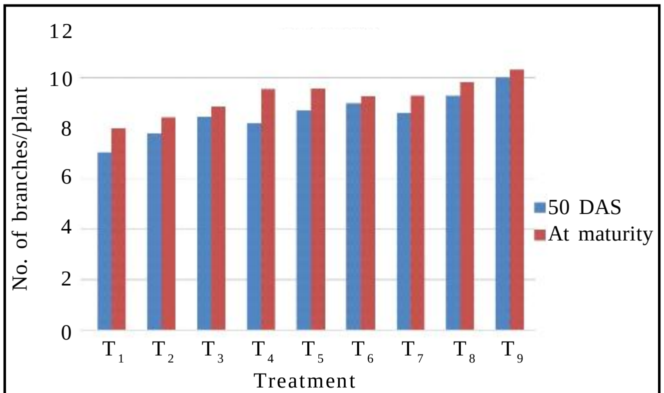

Fig. 2 : Effect of P×S interaction on number of primary branches

The data presented in Fig. 3 indicate that phosphorus and sulphur were significantly influenced the number of siliqua per plant at harvesting time but the P×S interaction were non-significant on the number of siliqua per plant at harvesting time. Application of 60 kg/ha phosphorus individually increased the number of siliqua of the plants about 9.42 per cent over the control. On the other hand, application of 30 kg/ha sulphur individually increased the number siliqua of the plants about 3.66 per cent over the control. Therefore, it was concluded that the effect of phosphorus was higher in magnitude than the effect of sulphur on the number of siliqua per plant at harvesting time. The combined effect of phosphorus and sulphur @ 60 kg P/ha and 30 kg S/ha gave the maximum increase (12.30%) to number of siliqua per plant over the control plots.

The data presented in Fig. 4 shows that phosphorus, sulphur and P×S interaction were significantly influenced the seed yield of mustard. Application of 60 kg/ha phosphorus individually increased the seed yield about 37.97 per cent over the control. Singh (2005) reported that the application of phosphorus significantly increase the seed yield. Application of 30 kg/ha sulphur individually increased the seed yield about 25.41 per cent over the

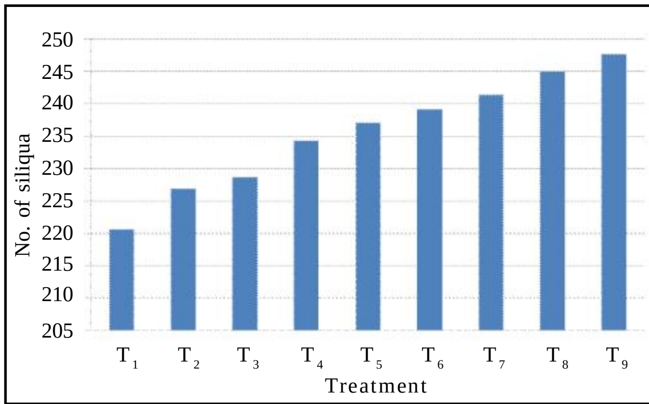

Fig. 3 : Effect of P×S interaction on number of siliqua/plant

control. Singh *et al.* (1997) also reported that the sulphur application improved of significantly plant biomass, seed and straw yield. The combined effect of phosphorus @ 60 kg P/ha and sulphur @ 30 kg S/ha produced the maximum seed yield about 45.15 per cent over control plots.

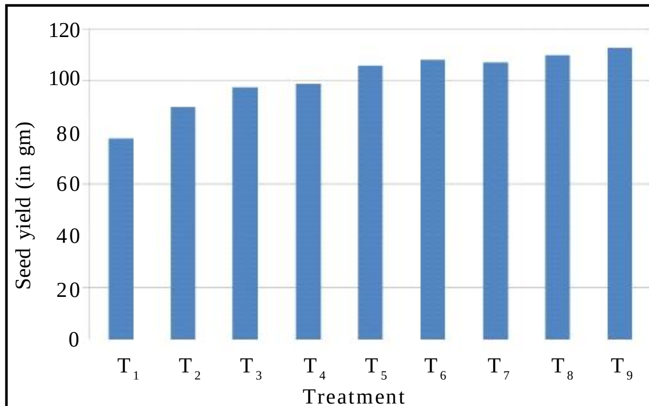

Fig. 4 : Effect of P×S interaction on seed yield of mustard

The perusal of data presented in Fig. 5 clearly indicate that phosphorus, sulphur and P×S interaction were significantly influenced the oil content of mustard seed. Minimum oil content (29%) was obtained in control plots, without phosphorus and without sulphur. Maximum oil content (41.82%) was obtained in the plot treated with 60 kg/ha phosphorus and 30 kg/ha sulphur that was calculated about 51.72 per cent extra over the control. Application of 60 kg/ha phosphorus individually registered (33.06%) oil content, which was recorded about 10.22 per cent over the control plots. On the other hand, application of 30kg/ha sulphur individually registered (37.55%), which was concluded about 25.16 per cent over the control. Therefore, it was concluded that the effect of sulphur was higher in magnitude than the effect of phosphorus on the oil content in mustard seed. The combined application or P×S interaction produced significant added effect on the oil content and resulted in the maximum oil content of mustard plant. Bhagat *et al.* (2005) reported that the application of 40 kg S ha^{-1} produced significantly highest seed yield, protein, oil content, protein and oil yield, concentration, uptake and availability of nitrogen, phosphorus and sulphur of crops.

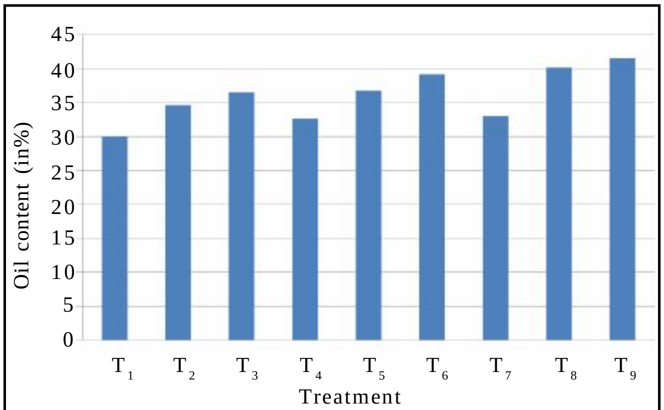

Fig. 5 : Effect of P×S interaction on oil content of mustard

Conclusion :

In this current study it was observed that the phosphorus and sulpher is not only beneficial for mustered crop but also their interaction in soil and plant is also effect the growth and yield of mustered and oil content. It is also observed that for growth and yield phosphorus is more important in compare to sulphur but for oil content sulphur is more important in compare to phosphorus. The best combination of phosphrous and sulphur in amount of 60 kg/ha and 30 kg/ha, respectively found most suitable for crop growth, yield and oil content of mustard.

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