Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 315-319

Ojoni Tekseng
Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University, Nagaland, India

PK Singh
Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University, Nagaland, India

Kevineituo Bier
Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University, Nagaland, India

Correspondence
PK Singh
Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University, Nagaland, India

Effect of phosphorus and sulphur nutrition on growth, yield and quality attributes of sesamum (*Sesamum indicum* L.) under acidic soil of Nagaland

Ojoni Tekseng, PK Singh and Kevineituo Bier

Abstract
A research investigation was conducted during *kharif* season 2015 to study the effect of phosphorus and sulphur nutrition on growth, yield and quality attributes of sesamum (*Sesamum indicum* L.) under acidic soil of Nagaland at the Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema campus, Nagaland. The experiment was carried out in a Factorial Completely Randomized Design comprising of 9 treatments P (0, 25 and 50 kg ha^{-1}) and S (0, 20 and 40 kg ha^{-1}) and each treatment was replicated three times. The study revealed that the growth parameters such as plant height, stem diameter and number of branches showed significant response to phosphorus and sulphur application at increasing rates after 30, 60, 90 days of sowing and at harvest except number of branches at 30 DAS was not significant but thereafter significantly affected by the treatment combinations. Highest growth attributes were found with $P_{50}S_{40}$. Significantly best yield and yield attributing parameters were obtained with $P_{50}S_{40}$. The oil content in seeds was significantly affected and highest was found with $P_{50}S_{40}$. The protein content increased with increased phosphorus levels.

Keywords: Growth, phosphorus, sesamum, sulphur, yield

Introduction
Sesamum (*Sesamum indicum* L.) is the most ancient oil seed crop of the world belonging to the family pedaleaceae. It is called the "Queen of the Seeds". Due to the presence of stable unsaturated fatty acid which causes resistance to rancidity, its seeds are called "Seeds of Immortality". Among the oil seed crops, sesame has the highest oil content of 46-64% with 25% protein (Thanunathan *et al*., 2002). It is a good source of vitamins and minerals such as calcium and phosphorous and the seed cake is also an important nutritious livestock feed.
The crop is grown in a wide range of environment, and being a short duration crop fits well into number of sequence and intercropping systems. It is grown in India both as *kharif* and *rabi* crops. In North Eastern Region, sesamum is grown as minor crops on relatively poor soils with no manures. This neglect is reflected in low average yields, contributing less than 5% to the national pool of oilseeds. During the year 2013-14 the area under Sesamum cultivation in Nagaland stretches to 3600 hectares and with production of 2200 tonnes (Anonymous, 2013-14). The region however has tremendous potential for increasing sesamum production and productivity due to favourable climatic condition.
Optimum nutrition is required for achieving good quality and maximum yield. The impact of phosphorus and sulphur fertilization of growth and yield of sesamum is scarce in acidic soils of Nagaland. Phosphorus is the second most important major nutrient for plants after nitrogen. It promotes early root formation and vital to seed formation by stimulating early flowering and thereby it brings an early maturity. The phosphorus requirement is high in oilseed crops because of its involvement in the synthesis of energy rich oil and proteins. Sulphur deficiency is widespread in India and considered as a limiting factor particularly for oilseeds and paddy (Sakal *et al.*, 2001). Oilseed crops require more sulphur than cereals as their oil storage organs are mostly proteins, rich in sulphur. Deficiency of sulphur is known to hamper nitrogen metabolism in plants as well as synthesis of S-containing amino-acids and thus exerts adverse effects on both seed and oil yield. The present investigations were planned to study the effect of phosphorus and sulphur nutrition on growth, yield and quality attributes of sesamum.

Materials and Methods
The present investigation was carried out at Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development (SASRD), Nagaland

University, Medziphema campus, Nagaland during the *kharif* season 2015.

The experiment was carried out in a Factorial Completely Randomized Design comprising of 9 treatments P (0, 25 and 50 kg ha^{-1}) and S (0, 20 and 40 kg ha^{-1}) and each treatment was replicated three times. Phosphorus was supplied through Diammonium phosphate while sulphur was supplied through elemental sulphur, applied in combination into the filled pots a day before sowing of the crop. The recommended dose (RDF) of Nitrogen at the rate of 30 kg ha^{-1} was applied through urea and Diammonium phosphate. Potash (as K_2O) at the rate of 30 kg ha^{-1} was applied through muriate of potash in each pot. Surface soil (10-15cm depth) was used for filling the earthen pots and each pot was filled with 10 kg of soil. The experimental soil was sandy clay loam in texture with pH 5.5, high in organic carbon (1.52%), medium in Nitrogen (288.5 kg ha^{-1}), Phosphorus (18.1 kg ha^{-1}), Potassium (189.01 kg ha^{-1}) and Sulphur (16.7kg ha^{-1}).

The different growth attributing parameters were recorded at 30, 60, 90 DAS and at harvest. The protein content of the seeds was calculated from the data of nitrogen content of the seeds by using the formula: Protein% = 6.25 x N% in seed. The oil content was determined using soxhelt extraction unit as per method described by AOAC (1980).

Results and Discussions

Effect of P and S on growth parameters

Plant height: Phosphorus application at increasing rate showed significant effect on the plant height at all the stages of growth. The significantly maximum plant height recorded at 30, 60, 90 days after sowing (DAS) and at harvest with P dose of 50 kg ha^{-1} were 31.60 cm, 116.50 cm, 130.60 cm and 142.50 cm respectively. Minimum plant height of 21.30 cm, 79.40 cm, 98.20 cm, 107.30 cm at 30, 60, 90 DAS and at harvest respectively, with zero phosphorus level.

Similarly, application of sulphur at increasing rates had significant effect on the plant height at all the growth stages of growth. The significantly maximum plant height at 30, 60, 90 DAS and at harvest were 29.70 cm, 108.10 cm, 124.20 cm, and 134.90 cm respectively were recorded for sulphur with 40 kg ha^{-1} sulphur. The minimum plant height 23.30 cm, 87.46 cm, 102.80 cm and 111.00 cm at 30, 60, 90 DAS and at harvest respectively were recorded with zero or no sulphur application.

The interaction of phosphorus and sulphur had significant effect on the plant height at all the growth stages of growth. At harvest the variation in plant height was from 88.90 cm to 153.60 cm. Treatment combinations $P_{50}S_{40}$ (153.60 cm) was significantly highest over control. The maximum plant height 35.70 cm, 125.66 cm, 141.86 cm and 153.60 cm were recorded for $P_{50}S_{40}$ at 30, 60, 90 days after sowing and at harvest respectively, whereas the minimum plant height of 18.90 cm, 67.20 cm, 83.70 cm and 88.90 cm at 30, 60, 90 DAS and at harvest was recorded for treatment combination P_0S_0.

The significant increase in plant height with phosphorus and sulphur application may be attributed to the fact that phosphorus and sulphur both promotes root growth and development of plants thus enhance the extraction of nutrients and moisture from soil more efficiently leading to better growth and development of plants. There by increases the nutrient uptake by the plant, This result is in accordance with the findings of Chaplot *et al*. (1996), Sharma and Gupta (2003), Okpara *et al.* (2007), Jadav *et al.* (2010) and Shelke *et al.* (2014).

Stem diameter of plants: Phosphorus application at increasing levels showed significant effect on the stem diameter at all the stages of growth. The significantly maximum stem diameter of the plants 0.43 cm, 1.15 cm, 1.50 cm and 1.68 cm were recorded at 30, 60, 90 DAS and at harvest respectively with P dose of 50 kg ha^{-1}. Minimum stem diameter of 0.36, 0.90, 1.26 cm, and 1.36 cm at 30, 60, 90 DAS and at harvest respectively, with zero phosphorus level.

Sulphur (S) application at increasing rates had significant effect on the plant height at all the stages of growth. The stem diameter (0.42 cm) of the plants were statistically similar at 30 DAS with 40 kg S ha^{-1} and 20 kg S ha^{-1}. At 60, 90 DAS and at harvest the largest stem diameter were 1.08 cm, 1.45 cm and 1.59 cm respectively recorded with sulphur levels of 40 kg ha^{-1} which was found to be at par with 20 kg ha^{-1} maximum over control. The smallest stem diameter 0.36 cm, 0.95 cm, 1.26 cm and 1.40 cm at 30, 60, 90 DAS and at harvest respectively were recorded with zero sulphur application.

The interaction of phosphorus and sulphur had significant effect at all the stages of growth. At harvest the variation in stem diameter of the plants was from 1.30 cm to 1.88 cm. Treatment combination $P_{50}S_{40}$ (1.88 cm) was significantly highest over control. The thickest stem diameter of plants 0.46 cm, 1.30 cm, 1.65 cm and 1.88 cm were recorded for $P_{50}S_{40}$ at 30, 60, 90 days after sowing and at harvest respectively which was at par with $P_{50}S_{20}$ whereas the minimum stem diameter of 0.30 cm, 0.0.90 cm, 1.20 cm and 1.1.30 cm at 30, 60, 90 DAS and at harvest was recorded for treatment combination P_0S_0.

The significant increase in stem diameter with phosphorus and sulphur application may be attributed to the fact that phosphorus and sulphur both promotes root growth and development of plants, energy transformation and cell division, there by increases the stem growth.

Number of primary branches: The effect of phosphorus and sulphur on number of branches per plant at 30 DAS showed statistically non-significant. There were no branches of the crop plants after 30 days of showing. However, thereafter phosphorus application at increasing levels showed significant effect at 60, 90 DAS and at harvest. The maximum number of branches per plant recorded were 4.89, 6.78 and 8.00 at 60, 90 DAS and at harvest respectively with P dose of 50 kg ha^{-1}, whereas minimum number of branches recorded were 2.55, 3.77 and 4.11 at 60, 90 DAS and at harvest respectively, with zero phosphorus levels.

There was no formation of branches of the plants at 30 days after sowing but with the advancement of growth the number of branches increases significantly. The maximum number of branches (4.45) at 60 DAS was recorded @ 40 kg S ha^{-1}. At 90 DAS and at harvest number of branches were 6.22 and 7.11 respectively recorded for sulphur (S) with 40 kg ha^{-1}. The minimum number of branches of 3.00, 4.00 and 5.00 at 60, 90 DAS and at harvest respectively were recorded with zero sulphur application.

There was no significant effect on number of primary branches at 30 DAS as there was no formation of primary branches. But with the advancement of growth, the interaction effect showed significant different at 60, 90 days after sowing and at harvest. At harvest the variation in number of branches per plants was from 3.33 to 10.00. Treatment combination $P_{50}S_{40}$ (10.00) was significantly highest over control which was at par with $P_{50}S_{20}$ (8.00). The maximum number of primary branches 6.00, 8.66 and 10.00 were recorded with

$P_{50}S_{40}$ at 60, 90 days after sowing and at harvest respectively, whereas the minimum 2.00, 3.00 and 3.33 at 60, 90 DAS and at harvest respectively was recorded for P_0S_0.

The number of branches increased with increased doses of phosphorus and sulphur. This result is in accordance with the findings of Okpara *et al.* (2007), Jadav *et al.* (2010) and Shelke *et al.* (2014). Increase in number of primary branches may be attributed to the role of phosphorus and sulphur in enhancing physiological processes such as cell division, cell elongation and chlorophyll formation.

Effect of P and S on Yield parameters

Number of capsules per plant at harvest: The phosphorus application at increasing levels showed significant effect on number of capsules per plant. The maximum number of capsules of 74.44 was recorded with P dose of 50 kg ha^{-1}, whereas minimum number of capsules of 31.00 was recorded at harvest with zero or no phosphorus levels.

Sulphur application at increasing levels showed significant effect on number of capsules per plant. The maximum number of capsules of 64.00 was recorded with S dose of 40 kg ha^{-1} and lowest number of capsules of 45.00 was recorded with zero or no sulphur levels.

The interaction effect of phosphorus and sulphur on number of capsules per plant shows significant effect. Treatment combinations $P_{50}S_{40}$ had significantly highest number of capsules (91.66) while P_0S_0 (24.33) was with lowest number of capsules.

The number of capsules increased significantly with increase in doses of phosphorus and sulphur. This may be attributed to the important role of phosphorus and sulphur on plant metabolism, cell division, cell development and seed formation. This result is in conformity with the findings of Okpara *et al.* (2007), Shehu *et al.* (2010), Jadav *et al.* (2010), Bhosale *et al.* (2011) and Shelke *et al.* (2014).

Test weight of seeds per plant: Phosphorus application at increasing levels showed significant effect on test weight of seeds. The maximum test weight of 1.76 g was recorded with P dose of 50 kg ha^{-1}, whereas minimum test weight of 1.49 g was recorded with zero or no phosphorus applications.

Sulphur application at increasing levels showed significant effect on test weight of seeds. The maximum test weight of 1.71 g was recorded with S dose of 40 kg ha^{-1} which was statistically at par with 20 kg ha^{-1} with 1.66 g and significantly higher over zero or no sulphur application. The minimum test weight of 1.57 g was recorded with zero or no sulphur application.

The interaction effect of phosphorus and sulphur on test weight per plant shows significant effect. Test weight of 1.84 g under treatment combination $P_{50}S_{40}$ was highest over other treatment combinations but statistically at par with test weight (1.75 g) of $P_{50}S_{20}$, the lowest test weight was recorded for P_0S_0.

The test weight of seeds per plant increased with increase in levels of phosphorus and sulphur. Similar beneficial effect of phosphorus and sulphur is in agreement with Shelke *et al.* (2014).

Seed yield per plant: The seed yield per plant increased significantly with increase in dose of phosphorus. The maximum yield of 9.58 g was recorded with P dose of 50 kg ha^{-1} and minimum seed yield of 5.05 g was recorded with zero or no phosphorus levels.

Sulphur application at increasing levels showed significant effect on seed yield. The maximum yield of 15.75 g was recorded with S dose of 40 kg ha^{-1} and lowest seed yield of 6.16 g was recorded with zero or no Sulphur levels.

The interaction effect of phosphorus and sulphur on seed yield per plant was significant and the variation in seed yield per plant was from 4.01 g to 11.12 g. Treatment combination of $P_{50}S_{40}$ yielded significantly highest over other treatment combinations with 11.12 g per plant and P_0S_0 with 4.01 g produced lowest seeds per plant.

The significant increase in seed yield per plant with increase in levels of phosphorus and sulphur and their interaction effect may be because of higher nutrient availability and their uptake with each increment level of phosphorus and sulphur which results in favourable condition for more seeds formation. This result is in conformity with findings of Mankar *et al*. (1995), Chaplot (1996), Sharma and Gupta (2003), Jadav *et al.* (2010) and Bhosale *et al.* (2011),

Stover yield per plant: The maximum yield per plant was recorded with P dose of 50 kg ha^{-1} with 16.44 g and minimum was recorded in zero or no phosphorus levels with 10.97 g. Phosphorus application at increasing levels showed significant effect on stover yield.

Sulphur application at increasing levels showed significant effect on stover yield. Sulphur levels @ 40 kg ha^{-1} produced maximum stover with 18.85 g per plant, whereas minimum stover yield per plant of was recorded in zero or no Sulphur levels with 11.81 g.

The interaction of phosphorus and sulphur on stover yield per plant shows significant effect. Treatment combinations $P_{50}S_{40}$ with 18.85 g produced maximum stover yield while the minimum stover yield was recorded in P_0S_0 with 9.56 g.

The significant increase in stover yield may be attributed to the synergistic relationship between phosphorus and sulphur that enhance the growth attributes and yield attributes which result in more dry matter accumulation with each increment level of phosphorus and sulphur. This beneficial effect of these two nutrients is in conformity with the finding of Shelke *et al.* (2014). The increase in dry matter yield per plant with increase in dose of phosphorus was cited by Behera *et al.* (1994) and that of sulphur was cited by Bhosale *et al.* (2011) and Sharma and Gupta (2003).

Effect of P and S on quality parameters

Protein content (%): Phosphorus application at increasing levels showed significant effect on protein content. The highest protein content of 23.70% was recorded with P dose of 50 kg ha^{-1} which was statistically at par with P dose of 25 kg ha^{-1} of 22.89% but significantly higher over with zero or no phosphorus levels of 21.02%.

With an increase in sulphur levels, the protein content of sesamum seeds increased but showed non-significant among the treatments.

The interaction effect of phosphorus and sulphur on protein content indicates that though all the other treatment combinations had higher protein content over control. The highest content was with highest dose of combined phosphorus and sulphur the application failed to show any significant variation. The significant increase in protein content in seeds with phosphorus might be due to more nitrogen content in seeds with application of phosphorus. This result is in agreement with the findings of Muthusamy *et al*. (1999).

Oil content (%): Phosphorus application at increasing levels showed significant effect on oil content. The highest oil content of 49.15% was recorded with P dose of 50 kg ha^{-1}, whereas lowest with 48.31% was recorded with zero or no phosphorus levels.

Sulphur rate at increasing levels also showed significant effect on oil content of sesamum seeds. Application of 40 kg S ha^{-1} produced significantly highest oil content of 50.21% and lowest of 46.90% was recorded with zero or no sulphur levels. The interaction effect was significant on the oil content and the variation in oil content with different treatment combinations was from 46.32% to 50.93%. The highest of 50.93% was recorded with treatment combination $P_{50}S_{40}$ which was significantly higher over other treatment combinations but at par with 50.19% in P_0S_{40}, and the lowest oil content of 46.32% was recorded in P_0S_0.

The highest oil content in $P_{50}S_{40}$ might be due to higher concentration of both phosphorus and sulphur. Phosphorus plays significant role in synthesis of energy rich oil and sulphur increase the number of oil storage organ particularly oil glands. Both are also essential for seed formation and attributes to the oil content in seeds. Pawar *et al.* (1993), Mankar *et al.* (1995) and Thanki *et al.* (2004) also reported increase in oil content in sesamum seeds with increase in phosphorus rates. Deshmukh *et al.* (2010) also found that every increment dose of S application correspondingly increase the oil yield.

Table 1: Effect of phosphorus and sulphur on plant height, stem diameter and number of primary branches at 30, 60, 90 DAS and at harvest

Treatments	Plant height (cm)				Stem Diameter (cm)				Number of primary branches			
	30	60	90	At harvest	30	60	90	At harvest	30	60	90	At harvest
P level (kg ha^{-1})												
P_0	21.30	79.40	98.20	107.30	0.36	0.90	1.26	1.36	-	2.55	3.77	4.11
P_{25}	27.40	104.20	117.20	127.30	0.41	1.02	1.33	1.48	-	3.88	5.00	6.11
P_{50}	31.60	116.70	130.60	142.50	0.43	1.15	1.50	1.68	-	4.80	6.78	8.00
SEm±	0.40	0.70	1.30	1.50	0.01	0.02	0.03	0.03	-	0.12	0.44	0.48
CD (P=0.5)	1.50	2.70	4.60	5.10	0.02	0.07	0.09	0.11	-	0.44	1.55	1.66
S level (kg ha^{-1})												
S_0	23.30	87.40	102.80	111.00	0.36	0.95	1.26	1.40	-	3.00	4.00	5.00
S_{20}	27.40	104.80	119.10	131.30	0.42	1.02	1.38	1.53	-	3.85	5.33	6.11
S_{40}	29.70	108.10	124.20	134.90	0.42	1.08	1.45	1.59	-	4.89	6.22	7.11
SEm±	0.40	0.70	1.30	1.50	0.01	0.02	0.03	0.03	-	0.12	0.44	0.48
CD (P=0.5)	1.50	2.70	4.6	5.10	0.02	0.07	0.09	0.11	-	0.44	1.55	1.66
PxS Interaction												
P_0S_0	19.00	67.20	83.80	88.90	0.30	0.90	1.20	1.30	-	2.00	3.00	3.33
P_0S_{20}	22.00	83.10	102.80	114.60	0.40	0.90	1.30	1.40	-	2.66	4.00	4.33
P_0S_{40}	23.20	88.10	108.00	118.50	0.40	0.90	1.30	1.40	-	3.00	4.33	4.67
$P_{25}S_0$	24.80	93.90	110.50	120.80	0.40	0.95	1.30	1.45	-	3.33	4.33	5.66
$P_{25}S_{20}$	27.20	108.30	118.50	128.60	0.41	1.05	1.40	1.50	-	4.00	5.00	6.00
$P_{25}S_{40}$	30.40	110.50	122.70	132.70	0.41	1.06	1.30	1.50	-	4.33	5.67	6.66
$P_{50}S_0$	26.20	101.20	114.10	123.30	0.40	1.01	1.30	1.45	-	3.66	4.67	6.00
$P_{50}S_{20}$	33.10	123.10	136.10	150.80	0.45	1.13	1.56	1.71	-	5.00	7.00	8.00
$P_{50}S_{40}$	35.70	125.70	141.80	153.60	0.46	1.30	1.65	1.88	-	6.00	8.66	10.00
SEm±	0.80	1.40	2.30	2.50	0.01	0.03	0.04	0.05	-	0.22	0.77	0.83
CD (P=0.5)	2.60	4.70	8.10	8.90	0.03	0.12	0.16	0.19	-	0.76	2.68	2.88

Table 2: Effect of phosphorus and sulphur on number of capsules, test weight, seed yield, dry weight of stover, protein content and oil content

Treatments	Number of capsules per plant (at harvest)	Test weight (g)	Seed yield per plant (g)	Dry weight of stover per plant (g)	Protein content (%)	Oil content (%)
P level (kg ha^{-1})						
P_0	31.00	1.49	5.05	10.97	21.01	48.31
P_{25}	58.56	1.69	8.10	14.68	22.89	48.43
P_{50}	74.44	1.76	9.58	16.44	23.70	49.15
SEm±	1.65	0.01	0.13	0.25	0.42	0.18
CD (P=0.5)	5.72	0.06	0.47	0.88	1.48	0.63
S level (kg ha^{-1})						
S_0	45.00	1.57	6.16	11.81	22.03	46.92
S_{20}	55.00	1.66	7.85	14.53	22.61	48.76
S_{40}	64.00	1.71	8.73	15.75	22.97	50.21
SEm±	1.65	0.01	0.13	0.25	0.42	0.18
CD (P=0.5)	5.72	0.06	0.47	0.88	NS	0.63
PxS Interaction						
P_0S_0	24.33	1.34	4.01	9.56	20.26	46.32
P_0S_{20}	31.34	1.54	5.21	11.28	20.97	48.43
P_0S_{40}	37.33	1.59	5.94	12.07	21.81	50.19
$P_{25}S_0$	54.00	1.67	6.89	12.54	22.28	47.40
$P_{25}S_{20}$	58.67	1.69	8.29	15.16	23.20	48.45
$P_{25}S_{40}$	63.00	1.71	9.14	16.32	23.21	49.46
$P_{50}S_0$	56.67	1.70	7.58	13.33	23.56	47.05
$P_{50}S_{20}$	75.00	1.75	10.05	17.14	23.66	49.01
$P_{50}S_{40}$	91.66	1.84	11.12	18.85	23.89	50.93
SEm±	2.86	0.03	0.23	0.44	0.74	0.31
CD (P=0.5)	9.91	0.11	0.82	1.53	NS	1.09

References

1. OAC. Official Methods of analysis (18th ed.), Association of Official Agricultural Chemists, Washington. Anonymous, 2013-14. Ministry of Agriculture, Government of India. 1960.
2. Behera, Mishra AK, Sha SKHS. Response of summer sesame (*Sesamum indicum* L.) to row spacing and phosphorus. Orissa Journal of Agricultural Research. 1994; **7**:99-101.
3. Bhosale ND, Dabhi BM. Gaikwad VP, Baviskar VS. Influence of different levels of potash and sulphur on yield attributes and yield of sesamum (*Sesamum indicum* L.) under south Saurashtra region. International Journal of Forestry and Crop Improvement. 2011; 2(1):88-90.
4. Chaplot PC. Effect of sulphur and phosphorus on the growth and yield attributes of sesame (*Sesamum indicum* L.). International Journal of Tropical Agriculture. 1996; 14(1/4):255-58.
5. Deshmukh, Duhoon MR, Alok Jyotishi SS. Effect of sources and levels of sulphur on seed yield, oil content and economics of (*Sesamum indicum* L.) in Kymore plateau zone of Madhya Pradesh (India). Journal of Oilseeds Research. 2010; 27(1):34-36.
6. Jadav, Padamani OP, Polara DR, Parma KB, Babaria KB. Effect of different level of sulphur and potassium on growth, yield and yield attributes of sesame (*Sesamum indicum* L.). Asian Journal of Soil Science. 2010; 5(1):106-08.
7. Mankar DD, Satao RN, Solanke VM, Ingole PG. Effect of nitrogen and phosphorus on quality, uptake and yield of sesamum. PKV Research Journal. 1995; 19(1):69-70.
8. Muthusamy, Gomez A, Jayabalan MPN. Effect of phosphorus nutrition on the growth of Sesamum indicum L. Journal of Phytological Research. 1999; 12(1/2):1-6.
9. Okpara DA, Muoneke CO, Ojikpong TO. Effects of nitrogen and phosphorus fertilizers rates on the growth and yield of sesame (*Sesamum indicum* L.) in the southeastern rainforest belt of Nigeria. Niger Agriculture Journal. 2007; 38:1-11.
10. Pawar PR, Patil RA, Khanvilkar SA, Mahadkar UV, Bhagat SB. Effects of different levels of nitrogen and phosphorus on yield and quality of sesamum. Journal of Maharashtra Agricultural Universities. 1993; 18(2):310-11.
11. Sakal R, Singh AP, Choudhary BC, Shahi B. Sulphur status of Ustifluvents and response of crops to sulphur application. Fertiliser News. 2001; 46:61-65.
12. Sharma HR, Gupta AK. Effect of sulphur on growth parameters and yield of some selected crops. Annal of Agricultural Research**.** 2003; 24(1):136-138.
13. Shehu HE, Kwari JD, Sandabe MK. Effects of N, P and K fertilizers on yield, content and uptake of N, P and K by sesame (*Sesamum indicum* L). International Journal of Agriculture and Biology. 2010; 12(6):845-50.
14. Shelke, Kalegore RI, Wayase NK. Effect of levels of phosphorus and sulphuon growth, yield and quality of sesamum. World Journal of Agricultura Sciences. 2014; 10(3):108-11.
15. Thanki, Patel JD, Patel AM. Effect of date of sowing, phosphorus and biofertilizer on growth, yield and quality of summer sesame, *(Sesamum indicum* L.) Journal of Oilseeds Research. 2004; 21(2):301-02.
16. Thanunathan K, Manickam G, Singharawal R. Studies on the influence of integrated nutrient management on growth, yield parameters and seed yield of Sesamum. Crop Research. 2002; 24(2):309-13