Research Article

Response of Different Sources and Levels of Sulphur in an Alluvial Soil of Varanasi on Growth and Yield Attributing Characters of Radish (*Raphanus Sativus* L.) Cv. Pusa Chetki

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Abstract

Field experiment was conducted during Rabi season 2014-15 at the experimental farm of the U.P. College, Varanasi, UP (India) on alluvial soil (sandy loam) of indogengetic plains, the experiment consisted in 3 replication and 16 different combination of sources & levels of sulphur. Investigate the response of different sources (Ammonium sulphate, Super phosphate, Gypsum, Potassium sulphate) and levels (0, 25, 50, 100 kgS/ha) on yield attributing characters in Radish *(Raphanus sativus L.)* cv. Pusa Chetki. The results revealed that application of Ammonium sulphate @ 50kgS/ha showed the economically significant superior in root length (25.87cm), root diameter (3.83 cm) and yield (258.66 q/ha). Applied sources of S, Ammonium sulphate had higher yield attributing characters compared to other sources of sulphur. It is involved in numerous metabolic activities, especially in amino acid and protein synthesis, plants assimilate inorganic sulphate into cysteine, which is subsequently converted into methionine. The agronomic consequences of decreasing yield due to insufficient S supply and even mild S deficiency is known to influence overall plants quality. The important role of S is energy transformation and enzyme activation in carbohydrate metabolism and subsequent greater photosynthates partitioning in yield formation.

Keywords: Ammonium Sulphate, super phosphate, Gypsum, Potassium Sulphate and Radish

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Introduction

Radish *(Raphanus sativus L.)* is most popular and widely grown cool season vegetables among the root crops. The most commonly eaten portion of the fusiform taproot, although the entire plant is edible and the tops can be used as a leaf vegetable. The seed can also be sprouted and eaten raw in a similar way to a mung bean, the root of Radish is usually eaten raw, although together specimens can be steamed. The raw flesh has a crisp texture and a pungent, peppery flavour caused by glucosinolates (4 methylthio- 3- Trans butenyl isothiocynate) and the enzyme myrosinase, which combine when cewed to from allyl isothiocynate also present in mustard, horse Radish.The seed of Radish can be present to extract Radish seeds contain up 48% oil content and while not suitable for human consumption this oil is a potential source of bio fuel the benefits of Radish in the treatments or prevention of jaundice, piles, urinary disorder, weight loss, cardiovascular condition, cancer, blood pressure, diabetes, skin disorder, fever, kidney disorder. Radish variety Pusa Chetki developed at IARI, New Delhi seed collect from Denmark in 1966 by selfing and massing to get desired type of roots with good tolerance to high temperature and humid weather condition. Roots are white, smooth, medium long (12.5 cm in the summer and 20.5 cm in rainy season) and almost stumpy, it is 40-45 days for attaining harvest maturity. Period of growing of this variety is fairly long from April to early September, the best season being from July to early September. It yields 200 -250 q/ha depending on season. sandy loams soil with a p^H 6.5 to 7.0 but for late season crop, a clay loam is ideal. Root of Radish is usually eaten raw and prevention for jaundice, piles, urinary disorder, weight loss, cardiovascular condition, cancer, blood pressure, diabetes, skin disorder, fever, kidney disorder. The sulphur is fourth essential plants nutrient after N, P and K in balanced fertilization. Radish root yield is reported to increase with S application **[1]**. Application of S as sulphate increases crop yield**[2]**. Sulphur application affects crop yield through the effect on S use efficiency and its components (uptake efficiency and utilization efficiency). This experiment was designed to gain a deeper insight into Radish S nutrition and relationship to economic yield **[3]** . S is involved in numerous metabolic activities, especially in amino acid and protein synthesis **[4, 5]**, earlier studies on glucosinolates concentrated on their toxic and anti nutritional effects**[6]**. Keeping the above points in mind the present investigations was undertaken with the following objective "Response of Radish to

different source and levels of sulphur in an alluvial soil of Varanasi on growth and yield attributing characters of Radish *(Raphanus sativus L.)* cv Pusa Chetki"

Materials and Methods

The experiment with 16 treatments were laid out in randomized complete block design in a factorial arrangement with sulphur sources and sulphur levels with three replications on well prepared field**.** The soil of experimental site was sandy loam with p^H 6.87 (Bechnan′s P^H meter), EC (dsm^{-1} at 25^0c) 0.15 (Electrical conductivity meter), Organic carbon (%) 0.44**[7]** , Available nitrogen (kg/ha) 212.56 (Alkaline permagnate method), Available Phosphorus (kg/ha) 37.32**[8]** Available potash (kg/ha) 210.05 (Normal ammonium acetate method by using flame photometer**[9]** Available sulphur (kg/ha) 8.85 (Method of**[10] were analyzed** . During the land preparation the whole quantity of farm yard manure at the rate of twenty tonnes per hectare was incorporated in the soil, 50 kg/ha nitrogen, 50 kg/ha phosphorus, and 50 kg/ha potash with the help of urea, DAP, and murate of potash, full dose of phosphorus, potash and half dose of nitrogen apply at the time of land preparation. Remaining dose of nitrogen was given in two split doses i.e. first fifteen days and second dose thirty days after sowing and full dose of different sources of sulphur fertilizer are applied before sowing as per treatment. The observation was recorded with the Interval of 15, 30 & 45 days after sowing from the 5 randomly selected plants.

Results and Discussion

Yield and yield attributing characters increase with increasing the levels of different sources of sulphur, The **Table 1** and **Figure 1** showed the maximum plant height with the replication was recorded in source of Ammonium sulphate @ 100 kg S/ha (57.54cm) followed by Ammonium sulphate @ 50 kg S/ha (57.44cm), Super phosphate @100kg S/ha (56.00cm), Super phosphate @50kg S/ha (55.60cm) and Potassium sulphate @ 100kg S/ha (54.90cm). The minimum plant height was noted in control, and all the above treatments are found to be significant with each other. No of leaves depicted from the **Table 2 and Figure 2**the maximum number of leaves was recorded to be 15.34 with application of Ammonium sulphate @ 100 kg S/ha followed by Ammonium sulphate @ 50 kg S/ha (15.33). Super phosphate @ 50kg S/ha (25.27), and Super phosphate @100kg S/ha (15.18) was found to be at par with each other, the minimum number of leaves (14.27) was found to be in control. The data related to the leaves length as given in **Table 3** and **Figure 3** observed the maximum leaf length 31.57cm was noted by the treatment Ammonium sulphate @ 50kg S/ha followed by Super phosphate @ 50kg S/ha (31.37cm), Ammonium sulphate @ 100kg S/ha (30.97cm), and Super phosphate @ 100kg S/ha (30.94cm), respectively.

Table 1 Response of different sources and levels of sulphur on plant height of Radish

Source/Level	0 KgS/ha	25 KgS/ha	50 KgS/ha	100 KgS/ha	Mean
Ammonium sulphate	49.16	51.39	57.44	57.54	57.540
Super phosphate	49.14	50.80	55.60	56.00	56.000
Gypsum	49.05	50.76	52.40	53.00	53.000
Potassium sulphate	49.05	50.74	53.64	54.90	54.900
Mean	49.100	50.923	54.770	55.360	_
CD at 5%					0.517

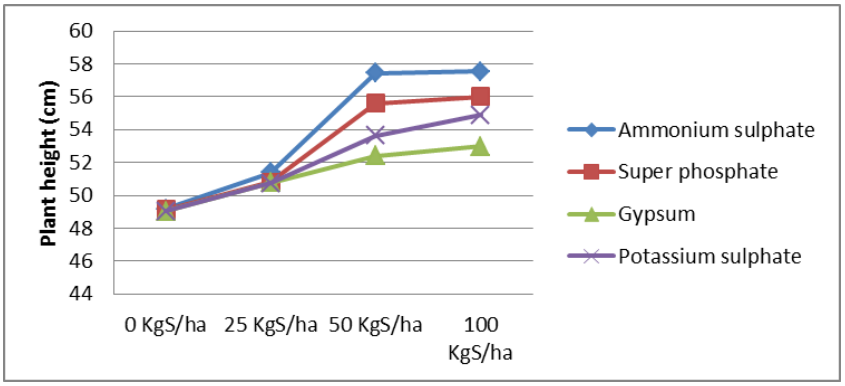

Figure1 Response of different sources and levels of sulphur on plant height of Radish

Table 2 Response of different sources and levels of sulphur on No of leaves of Radish

Source/Level	0 KgS/ha	25 KgS/ha	50 KgS/ha	100 KgS/ha	Mean
Ammonium sulphate	14.30	14.83	15.33	15.34	14.950
Super phosphate	14.27	14.64	15.27	15.18	14.840
Gypsum	14.30	14.49	15.00	14.93	14.680
Potassium sulphate	14.23	14.55	15.13	14.93	14.710
Mean	14.275	14.628	15.183	15.095	_
CD at 5%					NS

Table 3 Response of different sources and levels of sulphur on leaves length (cm) of Radish

Source/Level	0 KgS/ha	25 KgS/ha	50 KgS/ha	100 KgS/ha	Mean
Ammonium sulphate	26.53	27.97	31.57	30.97	29.260
Super phosphate	26.57	27.90	31.37	30.93	29.193
Gypsum	26.50	27.83	28.63	28.57	27.883
Potassium sulphate	26.55	27.87	29.70	29.20	28.330
Mean	26.538	27.893	30.318	29.918	_
CD at 5%					0.604

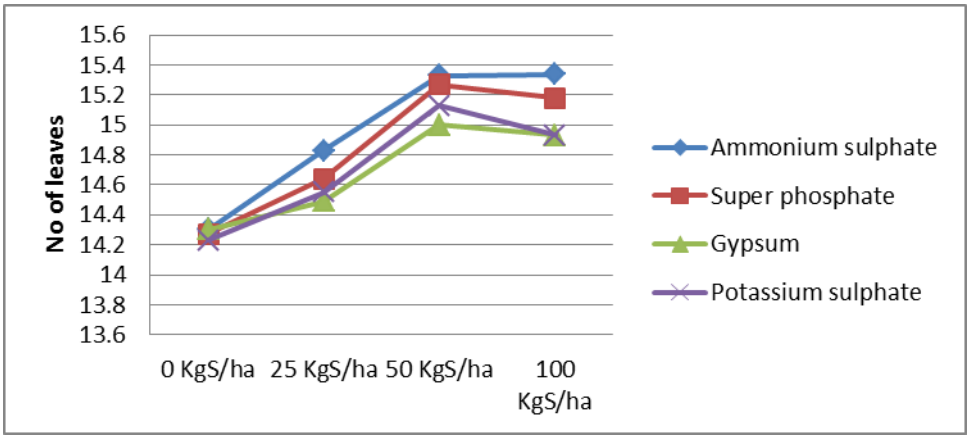

Figure 2 Response of different sources and levels of sulphur on No of leaves of Radish

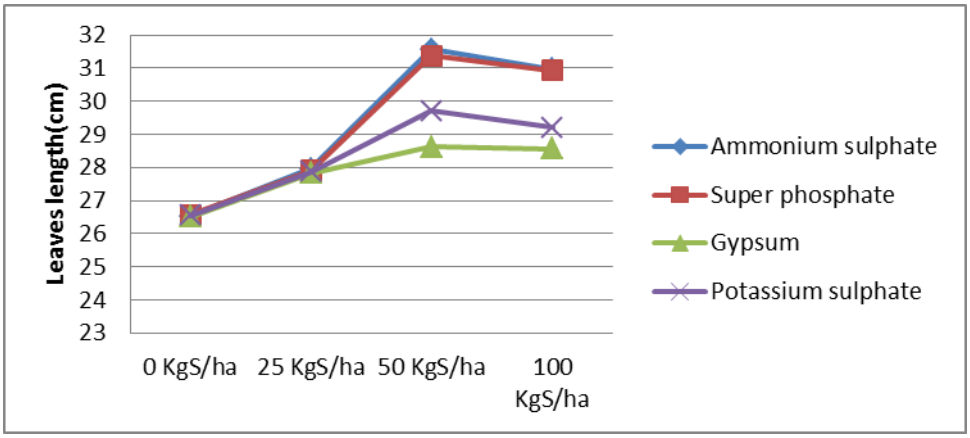

Figure 3 Response of different sources and levels of sulphur on leaves length of Radish

The minimum value were noted 26.54cm under 0kg S/ha and the minimum leaves width (Table 4 & Fig.4) was noted 7.59cm without application of source of sulphur. However, the maximum width was noted 10.77cm under Ammonium sulphate with application of 50kg S/ha followed by the treatment Ammonium sulphate @ 100kg S/ha (10.50cm), Super phosphate @ 50kg S/ha, Super phosphate @ 100kg S/ha (10.20) and Potassium sulphate @ 50kg S/ha (9.17cm) were statistically significant with each other. Ammonium sulphate is rich source of Sulphur and Nitrogen which increases the leaf length, leaf width, leaf weight, and total biomass which expressed greener, healthy plants and activates the more process of photosynthesis for the production of more photosynthates. **[11]** studied the

treatments with three source of sulphur i.e. single superphosphate, gypsum and elemental S, and 2 S levels, i.e. 20 and 40 kg/ha. Application of 40 kg/ha S on cabbage cv. Pride of India, recorded greater plant height, higher number of outer leaves and leaf area, and lower days required for initiation of head and maturity of head compared to other S level. Nitrogen at 80 kg/ha + S at 60 kg/ha, significantly increased siliqua of Indian mustard *(Brassica juncea L.)* per plant, seeds per siliqua, length of siliqua and test weight of seeds and also resulted in highest seed (2109 kg/ha) yield on pooled basis**[12]**. **[13]** evaluated the effect of four levels of nitrogen (0, 25, 50, 75 kg/ha) and three levels of sulphur (0, 20, 40 kg/ha) on growth, yield attributes of mustard *(Brassica juncea).* The application of nitrogen and sulphur significantly influenced the growth and yield of mustard. **[14]** studied the growth and yield attributes of Indian mustard *(B. juncea)* under various levels of sulphur (0, 20, 40, 60 and 80 kg/ha). Sulphur fertilization significantly increased the growth attributes, i.e. plant height, dry matter, leaf area index, relative growth rate (at initial vegetative growth stage), primary and secondary branches. Marked improvement was also observed in all yield contributing characters.

Table 4 Response of different sources and levels of Sulphur on leaves width (cm) of Radish

Source/Level	0 KgS/ha	25 KgS/ha	50 KgS/ha	100 KgS/ha	Mean
Ammonium sulphate	7.67	8.37	10.77	10.50	9.328
Super phosphate	7.57	8.60	10.40	10.20	9.193
Gypsum	7.63	7.69	8.20	8.37	7.973
Potassium sulphate	7.50	7.87	9.17	8.43	8.243
Mean	7.593	8.133	9.635	9.375	_
CD at 5%					0.355

Table 5 Response of different sources and levels of Sulphur on root length of Radish

Source/Level	0 KgS/ha	25 KgS/ha	50 KgS/ha	100 KgS/ha	Mean
Ammonium sulphate	22.63	23.42	25.87	26.57	24.623
Super phosphate	22.57	22.90	24.23	25.70	23.850
Gypsum	22.55	22.93	23.77	24.43	23.420
Potassium sulphate	22.50	22.87	23.94	25.57	23.720
Mean	22.563	23.030	24.453	25.568	_
CD at 5%					0.588

Table 6 Response of different sources and levels of sulphur on root diameter (cm) of Radish

Source/Level	0 KgS/ha	25 KgS/ha	50 KgS/ha	100 KgS/ha	Mean
Ammonium sulphate	2.87	3.33	3.83	4.20	3.558
Super phosphate	2.83	3.13	3.37	3.53	3.215
Gypsum	2.87	3.13	3.23	3.37	3.150
Potassium sulphate	2.87	3.30	3.20	3.43	3.200
Mean	2.860	3.223	3.408	3.633	_
CD at 5%					0.101

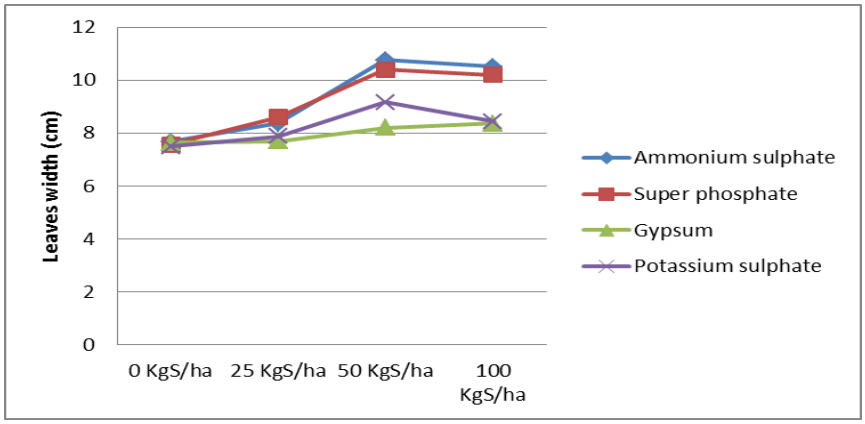

Figure 4 Response of different sources and levels of sulphur on leaves width of Radish

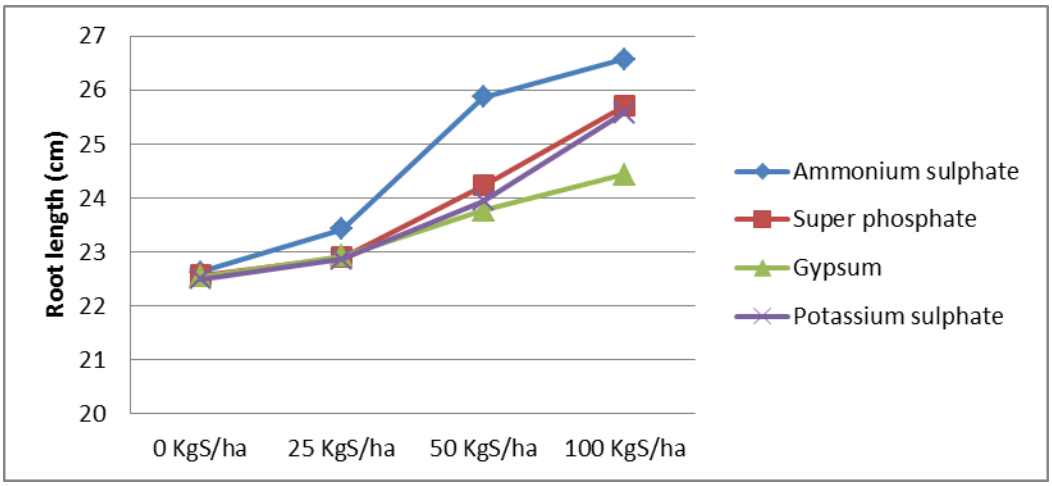

Figure 5 Interaction between sources and levels of root length on radish

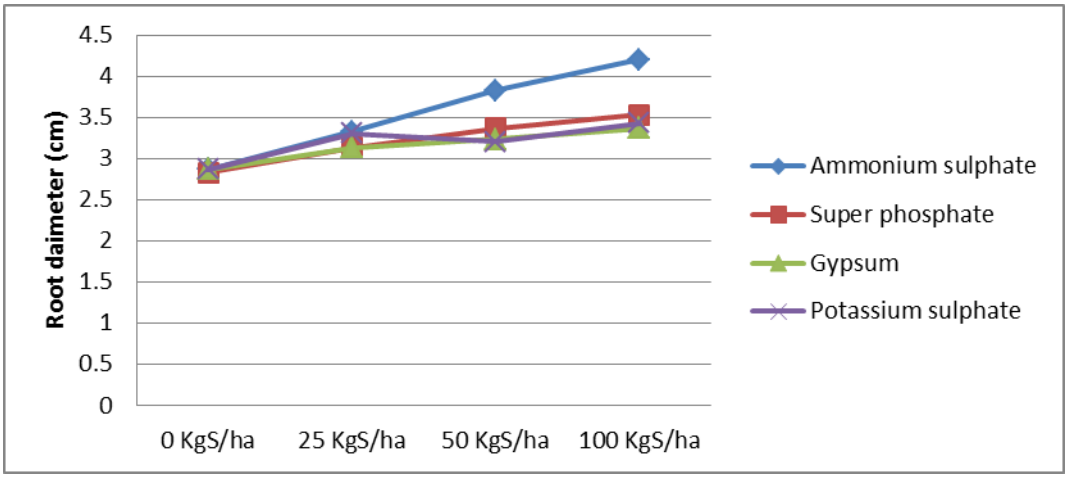

Figure 6 Interaction between sources and levels of root diameter (cm) on radish

Maximum root length was noted 26.57cm under treatment Ammonium sulphate @ 100kg S/ha followed by statistically 25.87cm under Ammonium sulphate@ 50 kg S/ha, 25.7cm under Super phosphate @100kg S/ha, 25.57 cm under Potassium sulphate @ 100kg S/ha(Table 5),the minimum 22.56cm was recorded in control. The root diameter measured with in 45 days 4.2 cm in Ammonium sulphate @ 100 kg S/ha followed by the treatment Ammonium sulphate @ 50 kg S/ha (3.83cm), Super phosphate @ 50kg S/ha (3.53cm), Potassium sulphate @ 100kg S/ha (3.43cm) and Gypsum @100 kg S/ha (3.37cm). While the minimum root diameter (2.86cm) was observed without application of any source of sulphur (Table 6) and the maximum yield observed 260.58q/ha in the treatment of Ammonium sulphate @ 100kg S/ha. This is closely followed by the Ammonium sulphate @ 50kg S/ha (258.66q/ha), Super phosphate @ 100kg S/ha (253.17q/ha) and Super phosphate @ 50kg S/ha (251.61q/ha) were noted statistically significant with each other. The minimum yield 236.81q/ha was noted with no application of any source of sulphur (Table 3 and Figure 3). Sulphur is involved in numerous metabolic activities, especially in amino acid and protein synthesis **[15]** & **[16]**. Plants assimilate inorganic sulphate in to cysteine, which is subsequently converted in to methionine **[17]**. The agronomic consequences of decreasing yield due to insufficient S supply and even mild S deficiency is known to influence overall plants quality **[18]**. The important role of S is energy transformation and enzyme activation in carbohydrate metabolism and subsequent greater photosynthates partitioning in yield formation **[19]** . The increase in the yield parameters might be attributed to easy availability of SO_4 sulphur present in Ammonium sulphate than other sources. Among the source of sulphur, maximum value of S use efficiency was recorded with ammonium sulphate followed by gypsum, elemental sulphur and pyrite. Sulphur uptake efficiency decreased markedly with increase rate of sulphur application. This is obvious because higher rate of sulphur leads to higher loses and nutrients uptake. Ammonium sulphate gave higher S uptake efficiency than other sources of sulphur**[20]**. Higher yield due to sulphur had already been reported by **[21]**, **[2]** & **[22]**.

These finding are also closely related with **[23]** who studied the effects of sulphur rate (0, 20, 40, and 60 kg/ha) on Indian mustard cultivars (Varuna, PBM-16, Rohini, and Pusa Bahar) in Agra, Uttar pradesh, India. Pusa Bahar

recorded the highest seed yield, weight, protein and oil contents, and total oil yield, whereas Rohini registered the highest number of leaves per plant. Seed yield, protein and oil contents, and oil yield increased with the increase in sulfur rate up to 40 kg/ha only. **[24]** Application of S fertilizer up to 60 kg/ha S hastened the maturity of the cabbage heads, head height, diameter and weight. **[3]**investigated the effect of sulphur on Radish cv. Pusa chetki. The graded rate of sulphur significantly increase root yield, S uptake and available S over the control. Application of S at 100 kg/ha gave highest root yield of 33.5 t/ha (season-1) and 36.8 t/ha (season-2) and also sulphur uptake and available sulphur. **[25]** revealed studied the 15-October-sown crops supplemented with 75 kg/ha S also gave the highest N (104.50 kg/ha) and S uptake (10.783 kg/ha). **[26]** evaluated the application of 10-30 kg/ha S increased *B. juncea* seed yield compared with controls (no S). The highest yield was given by 20 kg/ha S, with no significant difference between sources (gypsum, ammonium sulphate and single superphosphate) (**Table 7** and **Figure 7**).

Table 7 Response of different sources and levels of sulphur on yield (q/ha) of Radish

Source/Level	0 KgS/ha	25 KgS/ha	50 KgS/ha	100 KgS/ha	Mean
Ammonium sulphate	236.97	244.89	258.66	260.58	250.275
Super phosphate	236.57	244.11	251.61	253.17	246.365
Gypsum	236.84	243.49	247.10	248.11	243.885
Potassium sulphate	236.87	244.54	247.10	250.21	244.680
Mean	236.813	244.258	251.118	253.081	_
CD at 5%					3.394

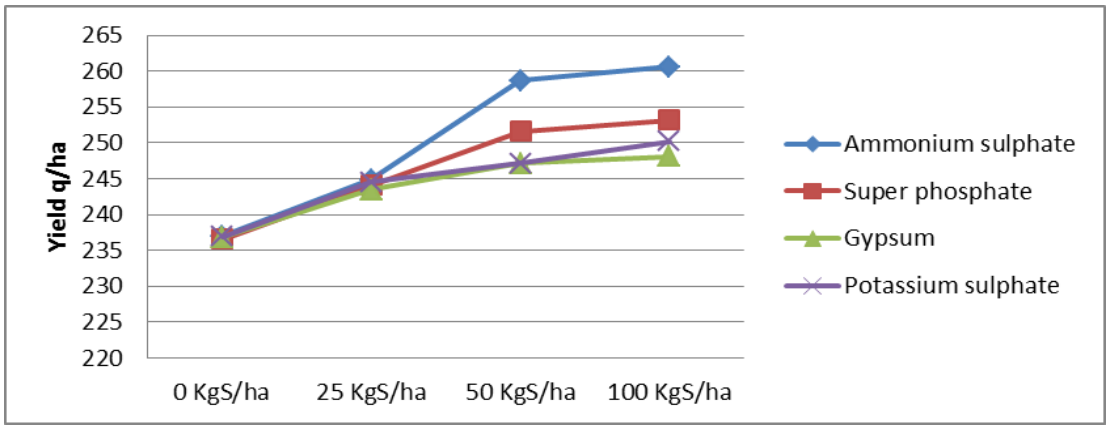

Figure 7 Interaction between sources and levels of yield (q/ha) on radish

Conclusion

It can be conducted from the above discuss that the different sources and levels of sulphur showed the significant response on growth and yield of Radish which may be obtained by the application of 100 kg S/ha through the ammonium sulphate. However, the soil health and economic point of view 50kg S/ha in the form of Ammonium sulphate will be best for the alluvial soil of Indogengetic plains of Varanasi region. Hence, it is recommended to use Ammonium sulphate @ 50 kg S/ha for optimum production of Radish.

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