International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(2): 943-947

Received: 01-01-2019
Accepted: 05-02-2019

Chaudhary KV
M.Sc. Student, Department of Soil Science and Agricultural Chemistry, Anand Agricultural University, Anand, Gujarat, India

Parmar JK
Associate Professor, Department of Soil Science and Agricultural Chemistry, Anand Agricultural University, Anand, Gujarat, India

Rathod TK
M.Sc. Student, Department of Soil Science and Agricultural Chemistry, Anand Agricultural University, Anand, Gujarat, India

Viradia MB
Associate Professor, Department of Soil Science and Agricultural Chemistry, Anand Agricultural University, Anand, Gujarat, India

Correspondence
Chaudhary KV
M.Sc. Student, Department of Soil Science and Agricultural Chemistry, Anand Agricultural University, Anand, Gujarat, India

Influence of phosphorus, sulphur and FYM on growth and yield of forage maize (*Zea mays* L.) grown on loamy sand soil

Chaudhary KV, Parmar JK, Rathod TK and Viradia MB

Abstract
The pot experiment was carried out at the Net House of the Department of Soil Science and Agricultural Chemistry, B. A. College of Agriculture, Anand Agricultural University, Anand on the "Influence of phosphorus, sulphur and FYM on growth and yield of forage maize (*Zea Mays* L.) grown on loamy sand soil" during summer season of the year 2017. The experiment was laid out in a completely randomized design (factorial) with three repetitions. The three levels of P_2O_5 (0, 30 and 60 kg ha^{-1}), three levels of S (0, 10 and 20 kg ha^{-1}) and two levels of FYM (0 and 10 t ha^{-1}) were tested in the experiment.
Application of P_2O_5 @ 60 kg ha^{-1} and application of S @ 20 kg ha^{-1} recorded significantly higher plant height at 30 DAS and at harvest than control. Significantly higher plant height was recorded with application of FYM @ 10 t ha^{-1} than control at 30 DAS as well as at harvest. Crop fertilized with P_2O_5 @ 60 kg ha^{-1} and FYM @ 10 t ha^{-1} gave significantly the highest green forage and dry matter yields, respectively. Similarly, application of S @ 20 kg ha^{-1} recorded significantly the highest dry matter, whereas application of S @ 20 kg ha^{-1} recorded higher green forage yield than rest of treatments, except S @ 10 kg ha^{-1}. The combination of phosphorus @ 60 kg ha^{-1} along with sulphur @ 20 kg ha^{-1} gave significantly higher green forage yield and dry matter yield than rest of the combinations except P_2O_5 @ 60 kg ha^{-1} with S @ 10 kg ha^{-1}. The combination of P_2O_5 and FYM (P_2O_5 @ 60 kg ha^{-1} with FYM @ 10 t ha^{-1}) recorded significantly higher dry matter yield of maize than rest of the combinations barring combination of P_2O_5 @ 60 kg ha^{-1} with FYM @ 10 t ha^{-1}.

Keywords: phosphorus, sulphur, FYM, forage maize

Introduction

Among various cereal crops, maize (*Zea mays* L.) is one the most important economic crops and is almost an ideal cereal forage crop because of its quick growing nature, high yield, palatable nutritious quality and lactogenic effect. Moreover, its wider adaptability over a range of environmental conditions and cropping season signifies as a good forage crop and provide nutritious fodder throughout year under all management practices. Maize is considered as the "Queen of Cereals". Maize is used as green fodder, straw, hay or silage. It can be safely fed at any stage of crop growth. In addition to this, maize is a C_4 in nature and it is highly adaptable to subtropical climate and can grow well even at high temperature. Maize grows well in wide range (5.5 to 8.0) of soil pH.

In India 45 to 48% of maize produced is consumed by human and the rest is used in cattle and poultry feed and by the starch and oil industries. Maize is utilized in many ways like other grain crops in food dishes including "Chapati".

Phosphorus is a fascinating and essential macro nutrient. It is involved in a wide range of plant processes from permitting cell division to the development of a good root system and for ensuring timely and uniform ripening of the crops. It is needed most by young fast growing tissues and performs a numbers of functions related to growth and development. In maize crop phosphorus helps in development of all phases and tend to delay maturity with an imperfect ear formation, if deficient. It shows its deficiency mainly at the seedling stage, though it is needed most after flowering stage (Barbers, 1995) [3].

Sulphur (S) is a building block of protein and a key ingredient in the formation of chlorophyll. Crops cannot reach their full potential in terms of yield or protein contents without adequate sulphur (Zhao, 1999) [24].

In crop production, sometimes sulphur is considered to be forgotten secondary nutrient. However it is most essential for activity of proteolytic enzymes and synthesis of amino acids.

If adequate supply of sulphur is ensured in the field it improves yield and quality of crops. The actual importance of sulphur has been noticed in the recent past due to exhaustive farming with high yielding varieties and the use of complex fertilizers, which led to sulphur deficiency in a lot of soils. Maize crop responds well to sulphur fertilization and it removes about 30-70 kg S ha^{-1}. Several workers have reported that uptake of major nutrients is also positively influenced by sulphur application (Bharathi and Poongothai, 2008) [4].

FYM is the source of primary, secondary and micronutrients, which are required for growth and development of crops. It is a constant source of energy for heterotrophic microorganisms, help in increasing the availability of nutrient and quality of crop produce. The entire amount of nutrients present in farmyard manure is not available immediately. About 30 per cent of nitrogen, 60 to 70 per cent of phosphorus and 70 per cent of potassium are available to the first crop. FYM improves soil physical properties like structure, water holding capacity etc. Carbon dioxide released during decomposition acts as a CO_2 fertilizer and plant parasitic nematodes and fungi are controlled to some extent by altering the balance of microorganisms in the soil.

Materials and Methods

A pot experiment was conducted during summer season of 2017 in the net house of the department of soil science and agricultural chemistry, Anand Agricultural University, Anand to carry out the study on "Influence of phosphorous, sulphur and FYM on growth and yield of forage maize (*Zea mays* L.) grown on loamy sand soil". The materials used and methods adopted for the research works are described below.

1. Collection of soil and processing for experimentation

A bulk soil samples from a depth of 15 cm were collected from agriculture research station, Khambhodaj, AAU, Anand. The samples were collected by adopting selected randomly pits and composited. The composite samples were brought to the laboratory, air dried and powdered with a wooden hammer and used for pot study to meet the objectives of as mention earlier.

2. Description of soil under study

The soils were analyzed for their physico - chemical properties. The soil collected from agriculture research station, Khambhodaj, AAU, Anand was of *Typic Ustochrepts*, having loamy sand soil texture, slightly alkaline in reaction (pH-8.05), whereas organic carbon contents, available N, S, Zn and Fe were low in status. While, the available K_2O and available P_2O_5 was medium in soil, whereas Mn and Cu contents were high in soil.

3. Pot Culture Study

A pot experiment was conducted to study the effect of levels of P, S and FYM on growth and yield of maize (African tall) grown on a loamy sand soil. The details of the treatments were as under (Table 3.2).

Table 3.2: Experimental details

	Treatment details	
(i)	(1) Phosphorus levels	P_1 : 0 @ kg ha^{-1} P_2 : 30 @ kg ha^{-1} P_3 : 60 @ kg ha^{-1}
	(2) Sulphur levels	S_1 : 0 @ kg ha^{-1} S_2 : 10 @ kg ha^{-1} S_3 : 20 @ kg ha^{-1}
	(3) FYM levels	F_0 : FYM @ 0 t ha^{-1} F_1 : FYM @ 10 t ha^{-1}
(ii)	Experimental design	CRD (factorial)
(iii)	Repetition	Three (03)
(iv)	Treatment combination	3 (P) × 3 (S) × 2 (FYM) = 18
(v)	Total no. of pots	18 × 3 = 54 pots
(vi)	Pot capacity	15 kg soil pot^{-1} (5 plants pot^{-1})
(vii)	Type of Soil	Loamy sand soil
(viii)	Crop and Variety	Maize (*Zea mays* L.), African-tall
(ix)	Date of sowing	05/03/2017
(x)	Date of harvesting	05/05/2017

The recommended dose of 80 kg N ha^{-1} applied as a urea, while phosphorus and sulphur applied as per treatment in the form of DAP and gypsum respectively, while FYM applied 10 days before sowing of the crop.

Results and Discussion

1. Effect of P, S and fym on plant height and yield of maize

1.1 Effect on plant height

The data pertaining to plant height of maize as influenced by application of P, S and FYM are given in Table 1.

1.1.1 Effect of phosphorus

Data pertaining to plant height of maize are given in Table 1. The influence of application of P was found significant on plant height of maize recorded at 30 DAS and at harvest. Significantly higher plant height (45.83 and 100.17 cm) was observed with application of phosphorus @ 60 kg ha^{-1} as compared to control at 30 DAS and at harvest but it was at par with 30 kg P_2O_5 ha^{-1}, respectively. While significantly the lower plant height (41.69 cm and 94.05 cm) was observed in control (0 kg P_2O_5 ha^{-1}) at 30 DAS and at harvest than rest of the treatments but it was at par with P_2 (30 kg P_2O_5 ha^{-1}).

The plant height under treatment P_3 (60 kg P_2O_5 ha^{-1}) and P_2 (30 kg P_2O_5 ha^{-1}) was increased to the tune of 9.93 and 8.17% at 30 DAS and 6.50 and 1.91% over control at harvest, respectively.

Phosphorus fertilization improves the various metabolic and physiological processes and thus known as "energy currency" which is subsequently used for vegetative and reproductive growth through photo-phosphorylation (pal *et al*., (2017) [10]. The results were conformity with finding of pal *et al*. (2017) [10], Patel *et al.* (2000) [12] and Raskar *et al*. (2012) [14] in maize.

1.1.2 Effect of sulphur

Addition of S significantly increases the plant height at 30 DAS and at harvest of maize plant (Table 1). Significantly the higher plant height (45.85 and 100.95cm) was observed with application of S_3 (S @ 20 kg ha^{-1}) as compared to control at 30 DAS and at harvest, but at par with S_2 (S @ 10 kg ha^{-1}). Significantly lower plant height (41.92 and 92.88 cm) was observed with control as compared to S @ 20 kg ha^{-1} at 30 DAS and at harvest and at par with S_2 @ 10 kg ha^{-1}. The increase in plant height of maize was 9.37 and 7.01% at 30 DAS and 8.69 and 3.63 per cent at harvest with respect to S_3 and S_2 treatment over control, respectively.

Better growth and development of maize plants due to higher levels of sulphur dose would have been due to multiple role of Sin protein and carbohydrate metabolism of plants by activating a number of enzymes which participate in dark reaction of photosynthesis hence increases the plant height and dry matter was observed with increased dose of S application (Jamal *et al.*, 2005) [7]. Thirupathi *et al*. (2016) [18] and Sheta (2007) [15] also reported similar result in maize crop.

1.1.3 Effect of FYM

The data presented in Table 4.1 indicated that plant height of maize was significantly influenced. The application of FYM @ 10 t ha^{-1} gave significantly highest plant height (45.38and 98.55 cm) as compared to no application of FYM (43.05 and 94.83 cm) at 30 DAS and at harvest with the tune of 5.41 and 3.92 percent over control. The plant height was increased due to the application of FYM @ 10 t ha^{-1} might be due to beneficial effect of FYM which improve physical and chemical condition of soil, improved fertility status of soil and better utilization of nutrient (Vyas *et al.*,1997) [21]. These results were in close conformity with finding of Sushila and Giri (2000) [16] who reported significant increase plant height of wheat with application of FYM @ 10 t ha^{-1} and Oad *et al.* (2004) [9] also reported significant increase in plant height of forage maize with application of FYM @ 10 t ha^{-1}.

1.1.4 Interaction effect

The interaction effects of P, S and FYM were found to be non-significant on plant height of maize recorded at 30 and at harvest.

Table 1: Influence of phosphorus, sulphur and FYM on plant height of maize

Treatments	Plant Height (cm)	
	30 DAS	At harvest
[A] P levels:		
P_1 : 0 kg ha^{-1}	41.69	94.05
P_2: 30 kg ha^{-1}	45.10	95.85
P_3 : 60 kg ha^{-1}	45.83	100.17
S.Em ±	0.88	1.55
C.D. (0.05)	2.53	4.45
[B] S levels:		
S_1 : 0 kg ha^{-1}	41.92	92.88
S_2 : 10 kg ha^{-1}	44.86	96.25
S_3 : 20 kg ha^{-1}	45.85	100.95
S.Em ±	0.88	1.55
C.D. (0.05)	2.53	4.45
[C] FYM levels:		
F_1 : 0 t ha^{-1}	43.05	94.83
F_2 : 10 t ha^{-1}	45.38	98.55
S.Em ±	0.72	1.27
C.D. (0.05)	2.06	3.63
[D] Interaction		
P×S	NS	NS
P×F	NS	NS
S×F	NS	NS
P×S×F	NS	NS
CV%	8.45	6.80

1.2 Effect of P, S and FYM on Yield

It appears from the results (Table 2) that the influence of P, S and FYM was found significant on green forage and dry matter yield of maize.

1.2.1 Effect of phosphorus

The data given in the Table 2 clearly indicated that the green and dry matter yield (348.77 and 57.64 g pot^{-1}) were significantly the highest observed with application of P_3 (60 kg P_2O_5 ha^{-1}) as compared to control and P_2 (30 kg P_2O_5 ha^{-1}). The application of phosphorus improves the root growth which has a great effect on the overall plant growth performance (Ayub *et al.*, 2002) [2]. The findings corroborate the reports of Pal *et al.* (2017) [10], Paramasivam *et al.* (2011) [11] and Rashid *et al.* (2012) [13]. While significantly the lowest green forage yield (286.23 g pot^{-1}) was observed with control as compared to application of phosphorus @ 30 kg ha^{-1} and 60 kg ha^{-1}. However, dry matter yield was observed significantly lower (48.54 g pot^{-1}) with control and at par with application of phosphorus @ 30 kg ha^{-1}. The green forage yield was improved to the extent of 21.85 and 18.75 per cent while dry matter yield improved to the extent of 12.18 and 4.61 percent in treatments of P_3 and P_2 over control, respectively. Promotion effect of high P level on plant height was probably due to better development of root system and nutrient absorption.

1.2.2 Effect of sulphur

The perusal of data given in Table 2 indicated that increasing of S application significantly increase the green and dry matter yield of maize. Significantly the higher green forage yield (342.22 g pot^{-1}) was observed with treatment of S_3 (20 kg S ha^{-1}) as compared to control and at par with the treatment S_2 (10 kg S ha^{-1}). While at harvest, significantly highest dry matter yield (60.52 g pot^{-1}) was observed with treatment of S_3 (20 kg S ha^{-1}) over control and S_2 (10 kg S ha^{-1}).Significantly the lowest green forage yield (284.44 and 43.64 g pot^{-1}) was observed with control.

The application of treatments of S_3 and S_2 were recorded 20.31 and 15.82 per cent higher green forage yield as well as 38.68 and 20.96 per cent higher dry matter yield were observed over the control, respectively. The application of sulphur attributed to enhanced crop growth rate, net assimilation rate and dry weight per plant, which ultimately increase in green forage and dry matter yield of maize.

Table 2: Influence of phosphorus, sulphur and FYM on green forage and dry matter yield of maize

Treatments	Yield (g pot^{-1})	
	Green forage	Dry matter
[A] P levels:		
P_1 : 0 kg ha^{-1}	286.23	48.54
P_2: 30 kg ha^{-1}	321.10	50.78
P_3 : 60 kg ha^{-1}	348.77	57.64
S.Em ±	6.48	1.30
C.D. (0.05)	18.59	3.73
[B] S levels:		
S_1 : 0 kg ha^{-1}	284.44	43.64
S_2 : 10 kg ha^{-1}	329.44	52.79
S_3 : 20 kg ha^{-1}	342.22	60.52
S.Em ±	6.48	1.30
C.D. (0.05)	18.59	3.73
[C] FYM levels:		
F_1 : 0 t ha^{-1}	306.47	48.03
F_2 : 10 t ha^{-1}	330.93	56.60
S.Em ±	5.29	1.06
C.D. (0.05)	15.18	3.05
[D] Interaction		
P×S	Sig.	Sig.
P×F	NS	Sig.
S×F	NS	NS
P×S×F	NS	NS
CV%	8.63	10.54

1.2.3 Effect of FYM

Application of FYM @ 10 t ha^{-1} (F_2) gave significantly the highest green and dry matter yield (330.93 and 56.60 g pot^{-1}) as compared to no application of FYM (306.47 and 48.03 g pot^{-1}), which was 7.98 and 17.84 per cent higher than control. FYM as a source of organic matter which improves soil structure and reduces soil compaction and also provides energy for N-fixation by free living heterotrophic microorganisms, it also plays important role in cycling of N and availability of nutrient in soil. Higher green fodder yield was the results of cumulative effect of increase in plant height, leaf-stem-ratio and leaf area index. These results were in close conformity with finding of Vyas *et al*. (1997) [21], Totawat *et al*. (2001) [19], Walia *et al*. (2007) [22] and Faujdar *et al*. (2014) [5]. The green and dry matter yield was increased due to the application of FYM which improve physical and biological condition of soil which reported by Negi *et al*. (1988) [8].

1.2.4 Interaction effect

The interaction effect of phosphorus and sulphur was found significant on green (Table 2a) and dry matter yield (Table 2b) of maize. Similarly, the interaction effect of phosphorus and FYM was also found significant on dry matter yield (Table 2c). However P × F, S × F, and P × S × F interaction found non-significant in case of green forage yield, while the interaction effect of S × F and S × P × F were also found non-significant in case of dry matter yield of maize.

1.2.4.1 Effect of P × S interaction

Combine effect of phosphorus and sulphur on the green forage and dry matter yield of maize is given in Table 2a and Table 2b, respectively.

Data pertaining to yield as influenced by P × S interaction showed increasing trend in yield with increasing level of S and P. Significantly the higher green yield (385.54 g pot^{-1}) was found in combination of P_3S_3 (60 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}) over the rest of treatments but it was at par with P_3S_2 (60 kg P_2O_5 ha^{-1} +10 kg S ha^{-1}). While, significantly lower yield (275.41 g pot^{-1}) was reported in combination of P_1S_1 (0 kg P_2O_5 ha^{-1}+ 0 kg S ha^{-1}), but it was at par with combination treatments of P_2S_1 (30 kg P_2O_5 ha^{-1}+ 0 kg S ha^{-1}), P_3S_1 (60 kg P_2O_5 ha^{-1}+ 0 kg S ha^{-1}), P_1S_2 (0 kg P_2O_5 ha^{-1} + 10 kg S ha^{-1}) and P_1S_3 (0 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}). While significantly higher dry matter yield (66.50g pot^{-1}) was observed in combination of P_3S_3 (60 kg P_2O_5 ha^{-1}+ 20 kg S ha^{-1}), but it was at par with P_3S_2 (60 kg P_2O_5 ha^{-1}+10 kg S ha^{-1}). Significantly lower yield (42.48 g pot^{-1}) was found in control (P_1S_1) and was at par with P_2S_1 (30 kg P_2O_5 ha^{-1}+ 0 kg S ha^{-1}), P_3S_1 (60 kg P_2O_5 ha^{-1}+ 0 kg S ha^{-1}) and P_1S_2(0 kg P_2O_5 ha^{-1} + 10 kg S ha^{-1}) treatment combinations. The synergistic effect of P and S may be due to utilization of high quantities of nutrients through their well-developed root system which might have resulted in better growth and yield reported by Wheeler *et al.*,1980 [23].

Table 2a: Interaction effect of phosphorus and sulphur on green forage yield (g pot^{-1}) of maize

Treatments	S_1 (0 kg ha^{-1})	S_2(10 kg ha^{-1})	S_3(20 kg ha^{-1})
P_1 (0 kg ha^{-1})	275.41	288.27	295.00
P_2 (30 kg ha^{-1})	277.29	339.89	346.11
P_3 (60 kg ha^{-1})	300.61	360.15	385.54
S.Em ±	11.22		
C.D. at 5%	32.19		
C.V.%	8.63		

Table 2b: Interaction effect of phosphorus and sulphur on dry matter yield (g pot^{-1}) of maize

Treatments	S_1 (0 kg ha^{-1})	S_2 (10 kg ha^{-1})	S_3 (20 kg ha^{-1})
P_1 (0 kg ha^{-1})	42.48	47.58	55.55
P_2 (30 kg ha^{-1})	44.19	48.64	59.51
P_3 (60 kg ha^{-1})	44.26	62.15	66.50
S.Em ±	2.25		
C.D. at 5%	6.46		
C.V.%	10.54		

1.2.4.2 Effect of P × F interaction

The data tabulated in Table 2c clearly indicated the interaction of P × F was affected significantly due to treatment combination on dry matter yield of maize. The highest dry matter yield (64.11 g pot^{-1}) was observed due to 60 kg P_2O_5 ha^{-1} along with 10 t FYM ha^{-1} (P_3F_2) over rest of treatments. The lower yield (46.74 g pot^{-1}) was observed in control (P_1F_1), but at par with P_2F_1 (30 kg P_2O_5 ha^{-1} + 0 t FYM ha^{-1}), P_3F_1 (60 kg P_2O_5 ha^{-1} + 0 t FYM ha^{-1}) and P_1F_2 (0 kg P_2O_5 ha^{-1} + 10 t FYM ha^{-1}) treatment combinations.

These might be due to application of FYM is improved aeration, bulk density, water holding capacity of soil which supported the better growth and development of root system for better uptake of nutrient from soil. The application of phosphorus along with FYM increased the utilization of applied phosphorus reported by Holmes, 1980 [6]. The results of present study are in agreement with those reported by syed

(2003) [17], Venkatesh *et al.* (2002) [20] and Ali *et al.* (2007) [1].

Table 2C: Interaction effect of phosphorus and FYM on dry matter yield (g pot^{-1}) of maize

Treatments	F_1 (0 t ha^{-1})	F_2 (10 t ha^{-1})
P_1 (0 kg ha^{-1})	46.74	50.34
P_2 (30 kg ha^{-1})	46.19	55.35
P_3 (60 kg ha^{-1})	51.16	64.11
S.Em ±	1.84	
C.D. at 5%	5.27	
C.V.%	10.54	

Conclusion

The results of the present investigation revealed that application of phosphorus @ 60 kg ha^{-1} + sulphur @ 20 kg ha^{-1} along with FYM 10 t ha^{-1} resulted in increased green forage yield and dry matter yield of forage maize.

References

1. Ali S, Bhatti AU, Ghani A, Khan A. Effect of farmyard manure (FYM) and inorganic fertilizers on the yield of maize in wheat-maize system on eroded inceptisols in northern Pakistan. Australian Agronomy Conference, 2007.
2. Ayub M, Nadeem MA, Sharar MS, Mahmood N. Response of Maize (*Zea mays* L.) fodder to different levels of nitrogen and phosphorus. Asian J. PI. Sci. 2002; 1:352-354.
3. Barbers SA. Soil nutrient bioavailability: a mechanistic approach. John wiley and sons. Fertilizers development and consultation. New York bio-fertilizers, 1995, 36-51.
4. Bharathi C, Poongothai S. Direct and Residual Effect of Sulphur on Growth, Nutrient Uptake, Yield and its Use Efficiency in Maize and Subsequent Greengram. Research Journal of Agriculture and Biological Sciences. 2008; 4(5):368-372.
5. Faujdar RS, Sharma M, Solanki RL, Dangi RC. Effect of FYM, biofertilizers and zinc on yield and micronutrients uptake in maize. An Asian Journal of Soil Science. 2014; **9**(1):121-125.
6. Holmes MRJ. Nutrition of the oilseed rape crop. Applied Science Publishers Ltd. London, 1980.
7. Jamal A, Fazli IS, Ahmad S, Abdin M, Yun SJ. Effect of sulphur and nitrogen application on growth characteristics, seed and oil yield of soybean cultivars. Korean journal of crop science. 2005; 50(5):340-345.
8. Negi SC, Singh KK, Thakur RC. Economics of phosphorus and FYM application in wheat maize sequence. Indian Journal of Agronomy. 1988; 37:30-33.
9. Oad FC, Buriro UA, Agha SK. Effect of organic and inorganic fertilizer application on maize fodder production. Asian Journal of Plant Sciences. 2004; 2(3):375-377.
10. Pal B, Hirpara DS, Vora VD, Vekaria PD, Sutaria GS, Akbari KN *et al*. Effect of Nitrogen and Phosphorus on Yield and Yield Attributes of Maize in South Saurashtra, India. Int. J Curr. Microbiol. App. Sci. 2017; 6(3): 22-26.
11. Paramasivam M, Kumaresan KR, Malarvizhi P. Effect of balanced nutrition on yield, nutrient uptake and soil fertility of maize in *vertisol* of Tamil Nadu. Indian Journal of Agronomy. 2011; 56(2):133-37.
12. Patel GJ, Patel GN, Goyal SN, Patel BG. Effect of phosphorus on the growth and yield of Hybrid Maize. G.A.U. Research Journal. 2000; 26(1):59-60.
13. Rashid M, Iqbal M. Effect of phosphorus fertilization on the yield and quality of maize (*Zea mays*) fodder on clay loam soil. The Journal of Animal and Plant Sciences. 2012; 22(1):199-203.
14. Raskar SS, Sonani VV, Shelke AV. Effects of different levels of nitrogen, phosphorus and zinc on yield and yield attributes of maize (*Zea mays* L.). Advance research journal of crop improvement. 2012; 6(2):126-128.
15. Sheta BT. Effect of nitrogen, potassium and sulphur levels on yield, quality and nutrient content and uptake of forage pearlmillet. Ph. D. thesis submitted to Anand Agricultural University, Anand, 2007.
16. Sushila R, Giri G. Influence of farmyard manure, nitrogen and biofertilizers on growth, yield attributes and yield of wheat (*Triticum aestivum*) under limited water supply. Indian Journal of Agronomy. 2000; 45(3):590-595.
17. Syed Ansar-ulHaq. Thesis Submitted to The Faculty of Post-graduate Studies Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir on Integrated nutrient management in maize (*Zea mays* L.) under irrigated Agro-ecosystem of Kashmir valley, 2003.
18. Thirupathi I, Vidya Sagar GE, Ch, Suneetha Devi KB, Sharma S. Effect of nitrogen and sulphur levels on growth, yield, quality and economics of single cross hybrid maize (*Zea mays*. L). International Journal of Science, Environment and Technology. 2016; 5(5):2989-2998.
19. Totawat KL, Jangir RK, Nagar GL, Jat SL. Effect of flyash on the performance of wheat on Ustochrepts of sub – humid plains of India.17th WCSS, 14-21 August 2002, Thailand, 2001.
20. Venkatesh MS, Majumdar B, Kumar K, Patiram. Effect of Phosphorus, FYM and Lime on Yield, P Uptake by Maize and Forms of Soil Acidity in *Typic Hapludalf* of Meghalaya. Journal of the Indian Society of Soil Science. 2002; 50(3):20-25.
21. Vyas SH, Modhwadia MM, Khanpara VD. Integrated nutrient management in wheat. Gujarat Agricultural University Research Journal. 1997; 23(1):12-18.
22. Walia SS, Kler DS, Khurana MPS. Heavy metal concentration in grain and soils as influenced by organic, integrated and chemical source of nutrition in maize-wheat system. Indian Journal of Plant Physiology. 2007; 12(2):212-214.
23. Wheeler JL, Hedges DA, Archer KA, Hmilton BA. Effect of nitrogen, sulphur, and phosphorus fertilizer on the production, mineral content and cyanide potential of forage sorghum. Aust. J Exp. Anim. Husb. 1980; 20:330-338.
24. Zhao FJ, Hawkesford MJ, McGrath SP. Sulphur assimilation and effects on yield and quality of wheat. J. Cereal. Sci., 1999; 30:1-17.