International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(6): 2097-2101

Received: 07-09-2019
Accepted: 09-10-2019

Assessment of potassium on soil fertility, nutrient uptake, of pearl millet in inceptisol

AR Deshmukh, MD Sarode and AN Deshmukh

AR Deshmukh
Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Dr. P.D.K.V, Akola, Maharashtra, India

MD Sarode
Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Dr. P.D.K.V, Akola, Maharashtra, India

AN Deshmukh
Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Dr. P.D.K.V, Akola, Maharashtra, India

Corresponding Author:
AR Deshmukh
Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Dr. P.D.K.V, Akola, Akola, Maharashtra, India

Abstract
A field experiment was conducted at Research Farm, Department of Soil Science and Agriculture Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season 2014-2015. The soil of experimental field was clayey in texture, moderately high in available nitrogen, moderate in available phosphorus, rich in available potassium with slightly alkaline in reaction. Five treatments with various combinations of fertilizer were compared with each other in Randomized Block Design with four replications. The treatments were- 1) NF (no fertilizer)), 2) RDF (recommended dose of fertilizer, 60:30:00 kg ha^{-1}), 3) RDF+15k$_2$O(60:30:00 + 15 kg K_2O ha^{-1}), 4) RDF+30k$_2$O(60:30:00 + 30 kg K_2O ha^{-1}), 5) RDF+45k$_2$O(60:30:00 + 45 kg K_2O ha^{-1}). Treatments were compared to evaluate the effect of different fertilizer levels on growth, nutrient uptake and economics of pearl millet. Experiment results revealed that fertilizer treatments significantly influenced the growth and nutrient uptake of pearl millet.
Significantly highest uptake of total NPK was deliberated with treatment of fertilizer consisting 45 kg ha^{-1} of potassium application. It was followed by treatment where potassium was applied to an extent of 30 kg ha^{-1}.
In nutshell it can be inferred that the treatments which received the fertilizer at the rate of 60:30:45 NPK kg ha-1 and 60:30:30 NPK kg ha^{-1}, both being at par with each other, improved the soil fertility status and profitability of the pearl millet crop.

Keywords: Pearl millet, potassium

1. Introduction
Soil fertility and its evaluation is one area which needs immediate attention since it is now established that an arrest in the productivity of several crops is due to ever decreasing soil fertility on one hand and an imbalanced application of plant nutrients on the other. The deficiency of several major and minor plant nutrients such as K, S, Ca, Zn. Fe and B are emerging in time and space (Srinivasa Rao, 2010; Srinivasa Rao and Vittal, 2007; Srinivasa Rao *et al*. 2010, 2007, 2003, 2000a, b, c) [1, 2].
Among the essential plant nutrients, potassium assumes greater significance since it is required in relatively larger quantities by plants and besides increasing the yield, it immensely improves the quality of the crop produce. Although a part of this K gap is expected to be bridged from non-chemical sources like organic manures like composts, vermicompost and biological processes, still there is a distinct gap in nutrient removal and supply leading to nutrient mining from the native soil posing a serious threat to long term sustainability of crop production furthermore, the country like India can hope to achieve and sustain the desired level of agricultural production in the long run only if we can bridge the gap between nutrient removal and addition. Therefore, understanding the present status of K use and removal and the resultant K balances with varied agro-climatic conditions enable us for undertaking the corrective measures to bridge the nutrient gap and help to maintain soil health and ensure the food and nutritional security of present and future generations (Satyanarayana, 2010). In addition, the growing concern about poor soil health and declining factor productivity or nutrient use efficiency has raised concern on the productive capacity of agricultural systems in Maharashtra, especially in Vidarbha region.
Agriculture in Vidarbha region of Maharashtra state is mostly rainfed. In rainfed crops, the importance to K fertilization is not given the attention it deserves, despite significant economic benefits that can be obtained. This is because of farmer’s lack of knowledge as well as their reluctance to increase inputs, given the uncertainty of crop cultivation in rainfed conditions. Moreover, as optimal K nutrition is of particular benefit to crops in providing drought

tolerance during intermittent dry spells in the rainfed environment, application of K may introduce additional benefits to farmers, beyond remedying the deficient soil K status.

Pearl millet (*Pennisetum glaucum* (L.)) is one of the major coarse grain crop, and is consider to be a poor man's food. In Vidarbha region, this crop is mostly identified as contingent crop. In Asia it is an important cereal crop of India, Pakistan, China, and south eastern Asia. Pearl millet grains contain about 11.6% protein, 5% fat, 67% carbohydrates and about 2.7% minerals. Its importance can't be ignored because it is the most drought tolerant and has the highest water use efficiency under drought stress.

When ICTP-8203, an open-pollinated variety of pearl millet developed at ICRISAT in 1982 from selection within an iniadi landrace from northern Togo. ICTP-8203 is still cultivated on over 200,000 ha, mostly in Maharashtra, but also in Andhra Pradesh, Karnataka, Rajasthan and Uttar Pradesh. This variety was found to have the highest level of iron density.

Due to intensive cropping, continuous mining and limited use of K fertilizers, soils have begun to show response to K fertilizers along with N, P fertilizers. In view of the above, it was proposed to study the effect of various levels of potassium on soil frtility status, nutrient uptake, yield and quality of pearl millet. The present study examines the impact of increasing levels of K fertilization on productivity, nutrient uptake and quality of rainfed pearl millet in Vidarbha region of Maharashtra state.

2. Material and Methods

A field experiment was conducted during *kharif* season of 2014-15. The field experiment was carried out at the Research farm of the, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Akola is situated in the subtropical region at $22^0$42' North latitude and 77^0 02' East longitudes and at an altitude of 307.42 m (Agromet observatory) above mean sea level. The climate of Akola is semi-arid and characterized by three distinct seasons viz., hot and dry summer from March to May, warm and rainy monsoon from June to October and mild cold winter from November to February. Average annual precipitation was 740 mm (Average of 30 years). During crop growing period, the actual maximum temperature was 34.2 ^{0}C during the hottest month of September while the minimum temperature was 9.8 ^{0}C in the coldest month of December. The mean daily evaporation reaches as high as 5.7 mm in the month of September and was 2.6 mm in the month of July. The mean wind velocity varies from 11.6 km hr^{-1} during August to 0.8 km hr^{-1} during October. Relative humidity attains the maximum value (89-95%) during July-August and the minimum (21-76 %) during December January.

The experimental site was fairly level and uniform in depth and topography. In order to know the soil fertility status of the experimental site, the soil samples from 15 to 30 cm depth were randomly collected from different locations of the experimental field before the start of the experiment and a composite sample was prepared and analyzed for various soil properties. The methods adopted to determine the important initial properties and data pertaining to them are presented in Table 1.

Table 1: Physical and chemical properties of experimental soil at the start of experiment.

Sr. No.	Soil properties	Value
1	pH	8.17
2	EC dSm^{-1}	0.28
3	Organic Carbon,g kg^{-1}	4.82
4	Available N, kg ha^{-1}	151.1
5	Available P, kg ha^{-1}	12.88
6	Available K,kg ha^{-1}	307

The experiment was laid out in Randomized Block Design with five treatments each replicated four times. The treatments were allotted randomly in each replication. The gross plot size was 4.5 m x 8.85 m. The net plot size was 3.6 m x 5.85 m.

3. Result and Discussion

Table 2: Available nutrient status (kg ha^{-1}) in soil after harvest of pearl millet by under various treatments.

Avaiable Nutrients (kg ha^{-1})			
Treatments	Available N	Available P	Available K
T1- Control	150.1	12.25	305
T2-RDF (60:30:00)	211.8	16.35	307
T3-RDF+15 kg K_2O ha^{-1}	213.1	16.65	353
T4-RDF+30 kg K_2O ha^{-1}	214.8	17.10	370
T5-RDF+45 kg K_2O ha^{-1}	216.1	17.45	382
SE(m)$\pm$	5.49	0.72	3.68
CD at 5%	16.52	2.12	8.24
Intial status	151.1	12.88	307

Available Nitrogen

The data in respect to final status of available nitrogen is presented in Table 2 and graphically represented in Fig 1.

Application of potassium significantly increases available nitrogen in soil after harvest of pearl millet. The highest available nitrogen was (216.1 kg N ha^{-1}) was observed in treatment T_5 (RDF + 45kg K_2O ha^{-1}) and found to be significantly at par with treatment T_4 (RDF + 30kg K_2O ha^{-1}) which obtained 214.8 kg N ha^{-1}. Also the treatment T_3 (RDF + 15kg K_2O ha^{-1}) was recorded 213.1 kg N ha^{-1} and it was at par with treatment T_2 (RDF 60:30:00) obtained 211.8 kg N ha^{-1}. The lowest available nitrogen was (150.1 kg N ha $^{-1}$) was obtained in treatment T_1 .i.e. control.While all treatments significantly superior over control treatments.The available nitrogen status after harvest of the crop was numerically increased as the dose of potassium were increased from 00 to 45 kg ha^{-1}. Similar results report of soil available nitrogen were also reported by Srinivasa Rao (2013) [6], Ali *et al.* (1991).

Available Phosphorus

The results regarding final status of available phosphorus are presented in Table 2 and graphically represented in Fig 1.

The available phosphours content of the soil was in the range of 12.25 to 17.45 kg P ha^{-1}. Application of potassium significantly increases available phosphours in soil after harvest of pearl millet. The highest available phosphours was (17.45 kg P ha^{-1}) was observed in treatment T_5 (RDF + 45 kg K_2O ha^{-1}) and found to be significantly at par with treatment T_4 (RDF + 30 kg K_2O ha^{-1}) which obtained 17.10 kg P ha^{-1}. Also the treatment T_3 (RDF + 15 kg K_2O ha^{-1}) was recorded 16.65 kg P ha^{-1} and it was at par with treatment T_2 (RDF 60:30:00) obtained 16.35 kg P ha^{-1}. The lowest available phosphours (12.25 kg P ha $^{-1}$) was obtained in treatment T_1

.i.e. control. While all treatments significantly superior over control treatments. Similar findings were recorded by, Paramasivan (2012) and Singh (2012). From the data, it can inferred that addition of K_2O certainly helps in improving the available phosphorus status under pearl millet cropping system.

Available Potassium

The values of final status of available potassium are presented in Table 2 and graphically represented in Fig 1.

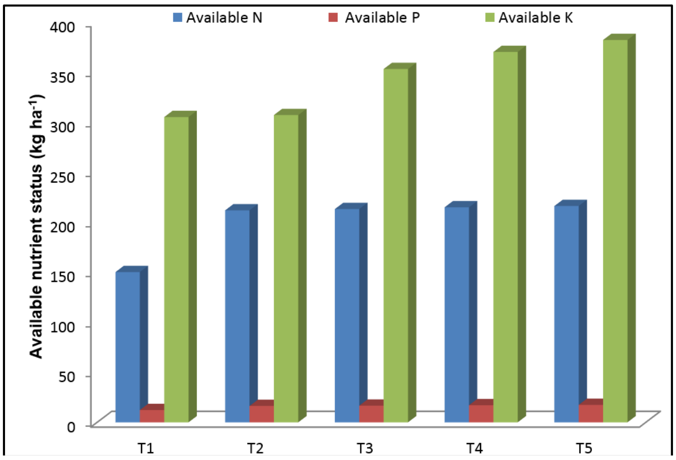

Fig 1: Available nutrient status (kg ha^{-1}) in soil after harvest of pearl millet by under various treatments.

It is indicative from the data that the addition of graded levels of K increased the availability of K and improved the soil fertility status even after high uptake by the crop. Application of potassium significantly increases available potassium in soil after harvest of pearl millet. The highest available potassium was (382 kg K_2O ha^{-1}) was observed in treatment T_5 (RDF + 45 kg K_2O ha^{-1}) and found to be significantly at par with treatment T_4 (RDF + 30 kg K_2O ha^{-1}) which obtained 370 kg K_2O ha^{-1}. Also the treatment T_3 (RDF + 15kg K_2O ha^{-1}) was recorded 353 kg K_2O ha^{-1} and it was at par with treatment T_2 (RDF 60:30:00) obtained 307 kg K_2O ha^{-1}. The lowest available potassium was (305 kg N ha $^{-1}$) was obtained in treatment T_1 .i.e. control. While all treatments significantly superior over control treatments.

Improvement in the soil fertility status due to RDF+45kg K_2O ha^{-1} may be attributed to release of K_2O from the less accessible sources including the non exchangeable fraction. This K_2O release was improved by higher uptake of exchangeable K_2O by the plant roots thus the soil having low K_2O availability have the tendency to match the K_2O demand of crop which is fulfilled by quantity of non exchangeable K_2O in soil and its rate of release from the soil fraction. Further, water soluble K_2O being a readily available source of K_2O, may be subjected to change either under cropping or external K_2O supply. This form of K_2O is in dynamic equilibrium with exchangeable K_2O and whatever change induced by crop removal of K_2O, is compensated by the release of exchangeable K_2O into solution. Hence, it can be presumed that; though the *vertisols* are supposed to be rich in available K_2O, can also respond to added K_2O up to 45 kg ha^{-1}. Similar results were reported by Shrinivsarao (2013) [6], Yadav (2008), Paramasivan (2012).

pH, EC and Organic carbon content

The data presented in Table 4 indicates that the pH values after harvest of pearl millet shows the differences in pH values ranged from (8.18 to 8.20). However, there were no significant change in pH was recorded in all the treatments. The lower value of pH 8.18 was noticed in the treatment of control (T_1). The highest value of pH 8.20 was noticed in the treatment of application of RDF(60:30:00) + 45 kg K_2O ha^{-1}.

The mean values of EC also change within the various treatments. EC values ranged from (0.29-0.31 dSm^{-1}). The higher value of (EC 0.33 dSm^{-1}) was observed in the treatment (T_4)RDF(60:30:00)+ 30 kg K_2O ha^{-1}. However, statistically there were no significant change in soil electrical conductivity in all the treatments. The findings on pH and EC values are in conformity with Muneshwar Singh (2006) [7].

Table 3: Effect of various treatments on chemical properties of soil after harvest of Pearlmillet

Sr. No.	Treatments	pH	EC (dSm^{-1})	OC (g kg^{-1})
T_1	control	8.18	0.29	4.84
T_2	RDF(60:30:00)	8.19	0.31	4.96
T_3	T_3-RDF+15 kg K_2O ha^{-1}	8.20	0.32	5.06
T_4	T_4-RDF+30 kg K_2O ha^{-1}	8.18	0.33	5.16
T_5	T_5-RDF+45 kg K_2O ha^{-1}	8.20	0.31	5.20
	SE(m)$\pm$	0.059	0.018	0.046
	CD at 5%	NS	NS	NS
Intial status (2012-13)		8.17	0.28	4.82

However, data revealed in above Table 3 shows the organic carbon status after harvest of soybean ranged between (4.84 to 5.20 g kg $^{-1}$). The highestsoil organic matter content was recorded in the treatment of RDF+ 45 kg K_2O ha^{-1} (5.20) (T_5), it was at par with the treatment where RDF+ 30 kg K_2O ha^{-1} (5.16) (T_4). Lowest organic carbon status were recorded in the control treatment. Numerical increase in organic carbon content the treatments were recorded with the treatment of potassium from 00 to 45 kg ha^{-1} along with RDF. However, statistically the results were non significant.

The similar findings were observed by Singh *et al.* (2005) Kundu (2008) [8], Yang *et al.* (2007) [9], and Subehia *et al.* (2013) [10].

Nitrogen uptake (kg ha^{-1})

The total uptake of nitrogen was increased and varies significantly. The nitrogen uptake varies from 20.08 to 58.20 kg ha^{-1}. The application of graded levels of K_2O as compared to RDF significantly influenced the uptake of nitrogen. Treatment receiving RDF+45kg K_2O ha^{-1} recorded highest total N in the plant to the tune of 58.20 kg ha^{-1}. It was followed by RDF+30kg K_2O ha^{-1} with an uptake of nitrogen 56.55 kg ha^{-1}. However, the nitrogen uptake by treatment T4 i.e. RDF + 30 kg K_2O ha^{-1} (56.55 kg ha^{-1}) was found statistically at par with treatment T5 (58.20 kg ha^{-1}), where the fertilizer K was applied upto 45 kg K_2O ha^{-1} along with RDF.

The nitrogen uptake recorded by the treatment of application of RDF i.e. T_2 (48.50 kg ha^{-1}) and application of RDF along with 15 kg K_2O ha^{-1} i.e. T_3 (49.88 kgha^{-1}) were found at par with each other.The increase in nitrogen uptake by treatment receiving 45 and 30 kg K_2O was found to an extent of 20 and 17 %, respectively over the RDF. Significantly lower nitrogen uptake was recorded in the control treatment i.e. T_1 (20.08 kg ha^{-1}). This increase application of fertilizer K_2O reflected on the increased uptake of nitrogen of pearl millet.

This behaviour specifies that plant requires adequate supply of K_2O for absorbing NO_3-N and maintaining high level of nitrate reductase activity. Similar result recorded by Ali *et al.* (1991).

Phosphorus uptake (kg ha^{-1})

The phosphours uptake ranged from 4.52 to 14.02 kg ha^{-1}. The phosphours uptake by pearl millet were significantly higher in all the treatments over control. However, the phosphorous uptake recorded in the treatment T_2 (12.78 kg ha^{-1}), T_3 (13.25 kg ha^{-1}), T_4 (13.92 kg ha^{-1}) and T_5 (14.02 kg ha^{-1}) were found statistically at par with each other. Significantly lower phosphours uptake was reported where no fertilizers were applied i.e. T_1 (4.52 kg ha^{-1}).

As RDF and other K_2O treatments recorded non-significant difference in uptake of phosphorus, it point out that there did not exist any direct correlation of K_2O over the uptake of phosphorus, even when K is present in abundance. These results are in conformity with AnandSwarup (1995).

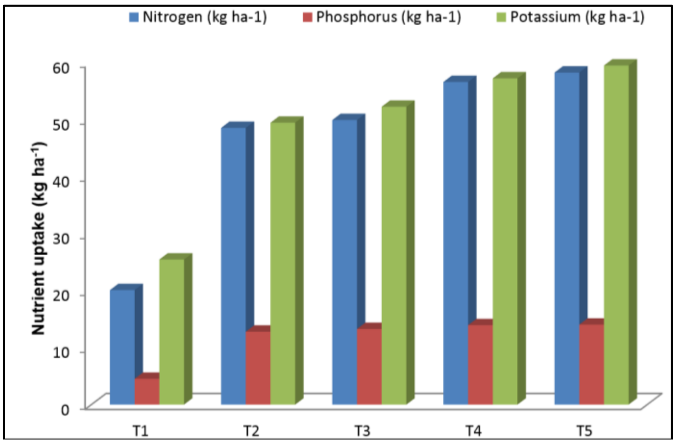

Fig 2: Nutrient uptake (kg ha^{-1}) as influenced by various fertilizer treatments

Potassium uptake (kg ha^{-1})

Uptake of K_2O significantly increased with the application of higher doses of potassium i.e. with RDF+45kg K_2O ha^{-1} and RDF+30kg K_2O ha^{-1} to an extent of 59.43 and 57.19 kg ha^{-1}. The added uptake of potassium over RDF by these two treatments was increased to the tune of 45.4 and 39%, however they were found at par with each other. When the potassium fertilization were applied at the rate of 15 kg K_2O ha^{-1} along with RDF there was significantly increased in K uptake over RDF treatment. As the dose of fertilizer K increased the from 15 to 45 kg ha^{-1} and also the uptake of K also increased.

Application of higher level of K_2O to pearl millet resulted in significantly increase in total K_2O uptake. K_2O actives plant enzymes functioning in the ammonium assimilation and transport of amino acids. The highest total uptake of K_2O in treatment receiving RDF+45kg K_2O ha^{-1}, therefore, may be attributed to higher available K_2O status at the exchangeable and non-exchangeable sites, high cation-exchange capacity of the soil, ensuing sufficient availability of K_2O at soil-root interphase. Similar results were reported by Tamboli *et al.* (2012) [12].

There are evidences that, more than half of exchangeable K_2O towards the crop uptake is mostly contributed from the soil depth below 15 cm. In case of treatment RDF+45kg K_2O ha^{-1} and RDF+30kg K_2O ha^{-1}, in this context, it is to point out that, there was a better root growth with RDF+45kg K_2O ha^{-1} and RDF+30kg K_2O ha^{-1} as compared to other treatments; resulting in additional absorption of exchangeable K_2O from the greater soil depth. Tondon and Sekhon (1988) [13], Srinivasa Rao (2013) [6] also reported the similar results. With addition of K_2O as an inorganic fertilizer, especially under *Vertisol* condition, in-solution and exchangeable K_2O are readily taken up by the roots from the soil solution. Hence under treatments RDF+45kg K_2O ha^{-1} and RDF+30kg K_2O ha^{-1}, due to addition of adequate amount of K_2O to the soil, there might have higher uptake by the plant with these two treatments. Significantly lower K_2O uptake was recorded in control treatment.

Table 4: Total Nutrient uptake (kg ha^{-1}) as influenced by various fertilizer treatments

Treatments	Total Nutrient uptake (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
T- Control	20.08	4.52	25.43
T_2- RDF(60:30:00)	48.50	12.78	49.41
T_3- RDF+15 kg K_2O ha^{-1}	49.88	13.25	52.21
T_4- RDF+30 kg K_2O ha^{-1}	56.55	13.92	57.19
T_5- RDF+45 kg K_2O ha^{-1}	58.20	14.02	59.43
SE(m)±	1.71	0.81	0.75
CD (5%)	5.18	2.61	2.30

4. Conclusion

From the above observations it is conclude that, significantly highest nutrient uptake, improvement soil fertility status of pearl millet were recorded by the applications of RDF(60:30:00 NPK kg ha^{-1}) along with 45 kg K_2O ha-^{1}. However the nutrient uptake, improvement soil fertility status were at par with RDF(60:30:00 NPK kg ha-1) along with 30 kg K_2O ha^{-1}.

5. References

1. Srinivasa Rao CH. Analysing Nitrogen use efficiency in relation to potassium in long-term manurial trials in dryland agriculture. IPI-FAI round table discussion on “analyzing nutrient use efficiency in relation to potassium”, fertilizer association of India, New Delhi 9-6-2010, New Delhi, 2010.
2. Srinivasa Rao CH. Rationalizing potassium fertilizer recommendations in Indian agriculture. XIV Sukumar Basu Memorial lec. Indian Agri. Res. Insti. New Delhi, feb, 13th, 2010.
3. Srinivasa Rao CH, Subba Rao A, Singh SP. Non exchangeable potassium release in one molar nitric acid: Evaluation of different modes of boiling the soil-acid suspension. comm. Soil Sci. Plant. Anal. 2000c; 31:905-911.
4. Srinivasa Rao CH, Subba Rao A, Bansal SK. Relationship between some forms of potassium and neutral normal ammonium acetate extractable K in major soil series of India. J Indian Soc. Soil Sci. 2000b; 48:27-32.
5. Srinivasa Rao CH, Subba Rao A, Rupa TR. Plant mobilization of reserve potassium from fifteen smectitic soils in relation to mineralogy and soil test potassium. Soil Sci. 2000a; 165:578-586.
6. Srinivasa Rao CH. Impact of potassium on crop productivity, use efficiency, uptake and economics of some rainfed crops in Andhra Pradesh, southern India, 2013.
7. Muneshwar, Singh RH, Wanjari. Annual Report 2006-2007 AICRP on Long term fertilizer experiments to study changes in soil quality, crop productivity and sustainability. Ind. Insti. Soil Sci. (ICAR), Bhopal, 2006.

8. Kundu S, Bhattacharya R, Ved Prakash, Gupta HS. Carbon sequestration potential of Inceptisols under Long - Term Soybean - wheat rotation in sub temperate rainfed Agro-ecosystem of North - West Himalayas., j Ind. Soc. Soil Sci. 2008; 56(4):423-429.
9. Yang SM, Li FM, Malhi SS, Wang P, Suo DR, Wang JG. Long - term effects of manure and fertilization on soil organic matter and quality parameters of a calcareous soil in North-western China. J Plant Nutr. Soil Sci. 2007; 170:234-243.
10. Subehia SK, Sepehya S, Rana SS, Negi SC, Sharma SK. Long - term effect of organic and inorganic fertilizers on rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L.) yield, and chemical properties of an acidic soil in the western Himalayas. Expl. Agric. 2013; 49:382-94.
11. Anand Swarup. Phosphorus and potassium fertilization of pearl millet and grown on a reclaimed saline soil. J. Pot. Res. 1995; 11(2):185-192.
12. Tamboli BD, Pawar AB, Bagwan IR, Bhanavase DB, Patil GD, Takate AS *et al*. Response of rabi sorghum varieties to potassium levels in, 2012.
13. Tondon HLS, Sekhon GS. Potassium research and Agricultural situation in India. Fertilizer development consultation organisation, New Delhi 1988, 15-37 and 122-123.