The Pharma Innovation Journal 2021; 10(4): 875-879

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(4): 875-879

www.thepharmajournal.com
Received: 07-02-2021
Accepted: 11-03-2021

Yaseen Shareef
Alpine Institute of Management and Technology, Dehradun, Uttarakhand, India

Narender Kumar
Alpine Institute of Management and Technology, Dehradun, Uttarakhand, India

Ritu Sharma
Alpine Institute of Management and Technology, Dehradun, Uttarakhand, India

Ankush Singh
Alpine Institute of Management and Technology, Dehradun, Uttarakhand, India

Pragya Rawat
Alpine Institute of Management and Technology, Dehradun, Uttarakhand, India

Corresponding Author:
Yaseen Shareef
Alpine Institute of Management and Technology, Dehradun, Uttarakhand, India

Physiological parameters of lentil under integrated nutrient management

Yaseen Shareef, Narender Kumar, Ritu Sharma, Ankush Singh and Pragya Rawat

Abstract
Investigation was carried out at the Crop Research Centre, Alpine Institute of Management and Technology, Dehradun, Uttarakhand during *rabi* season of 2018-19 to study the effect of integrated nutrient management on physiological parameters of lentil. The experiment was laid out in randomized complete block design with ten treatments replicated thrice. The lentil plants supplied with NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha exhibited maximum leaf area, leaf area index, crop growth rate and net assimilation rate. Further, this treatment recorded higher grain yield per hectare (1072.93 kg/ha) and straw yield per hectare (1841.31 kg/ha). Hence, the application of NPKS @ 15:20:15:15 kg/ha along with FYM @ 8 t/ha proved beneficial for realizing higher yields of lentil.

Keywords: NPK, FYM, integrated nutrient management, physiological parameters, yield, lentil

Introduction
Lentil (*Lens culinaris Medikus*) is a protein-rich winter season pulse crop. It is a leguminous crop and capable of meeting its partial nitrogen requirement by fixing the atmospheric nitrogen. The yield level of lentil is generally low because it is a less cared crop and mostly grown in poor soils under rainfed conditions without manures and fertilizers. Regular depletion of nutrient resources of soils has led to the emergence of several nutrients deficiencies in many crops including lentil. Although increased crop production is attributed to genetic improvements and extensive chemical fertilizer applications, overreliance on synthetic chemical fertilizers has resulted in serious environmental hazards, deteriorated soil properties and decreased crop yields over time (Hepperly *et al.*, 2009) [10]. The implication of organic manures (OM) in crop production not only improves soil physicochemical properties but also increases crop productivity and is eco-friendly, cheap, readily available and a potential source of nutrients (Gangwar *et al.*, 2006) [6]. However, OM cannot overcome the nutritional requirements of crops over the broad zones alone as it contains reduced and imbalanced amounts of nutrients and its application is labor-intensive due to its bulky nature (Jones *et al.*, 2010) [11]. Due to their limitations, neither inorganic fertilizers nor OM can ensure sustainable crop productivity when applied separately (Arif *et al.*, 2016) [2]; however, an integrated nutrient management system (combined use of inorganic as well as organic fertilizers) could be the best alternative strategy for maintaining and/or restoring the fertility of soil and productivity of crops on a sustainable basis (Guerena *et al.*, 2016). For sustainable production system, integrated use of chemical fertilizers, organic manures such as farmyard manure (FYM) or vermicompost, or through the use of biofertilizers such as Rhizobium and phosphate solubilizing bacteria (PSB) helps to meet the nutrient requirement of the crop and providing high productivity (Meena and Ram, 2016) [13]. The addition of organic manures increases organic carbon, aggregate stability, moisture retention capacity and infiltration rate of the surface soil while reducing the bulk density and also improves grain yield of lentil (Sarkar *et al.*, 2003) [17]. Application of biofertilizers (Singh *et al.*, 2016), nitrogen (Niri *et al.*, 2010) [14] and phosphorus (Rasheed *et al.*, 2010) [16] is known to improve plant growth and grain yield in lentil. The supply of organic and microbial sources of nutrients to plants has an added advantage of consistent and slow release of nutrients maintaining ideal C:N ratio and improving water holding capacity and microbial biomass of soil profile without having any residual effects. The physiological parameters are an important indicator of radiation and precipitation interception, energy conversion, and water balance. This is the reason why most studies in agronomy and horticulture measure the results of interventions such as

fertilizers and irrigation in terms of these parameters as well as yield. Thus, an attempt has been made to assess the effect of integrated nutrient management with an emphasis on FYM, vermicompost and biofertilizers on physiological parameters and yield of lentil.

Materials and methods

Depiction of Experimental Location and Crop

A field experiment was conducted at Crop Research Centre, Alpine Institute of Management and Technology, Dehradun, Uttarakhand, (29^0 58' and $31^0$2'30" north latitudes and $77^0$34'45" and $78^0$18'30" east longitudes) during *rabi* season of 2018-19. This region is categorized as a temperate climate and received 1734.1mm rainfall, concentrated in the monsoon period (July to October 2018). The maximum and minimum temperature recorded during the growing season of crop *i.e.* October 2018 to March 2019 was 25℃ and 3℃ respectively. The soil of the experimental area was sandy loam characterized by coarse sand, fine sand, silt and clay at 0.71, 65.2, 18.6 and 15.70, respectably. With regard to physiochemical properties, the soil had an organic carbon content of 0.42 %, pH of 7.12, available N of 200 kg/ha, available P of 9.1 kg/ha and available K of 181 kg/ha. A randomized complete block scheme with three repetitions was used and every plot size was 5.0 m × 3.0 m. An inter-row spacing of 30 cm was used. A lentil variety (Pant Masoor- 5) which is suitable to be grown in this area was used with a seed rate of 30 kg/ha.

Treatments Application and Management

The experiment consisted of ten treatments, including uses of organic and inorganic fertilizers separately and in combinations (Table 1). The fertilizers as per the treatments were applied in the required quantities. The doses of NPKS were applied in the form of urea, diammonium phosphate, murate of potash and gypsum respectively. The pre-sowing application of FYM and vermicompost was done in the soil. Rhizobium culture + PSB was applied as seed treatment @ 5g/kg seed.

Table 1: Description of treatments applied in the study

T_1: Control
T_2: NPKS (15:20:15:15kg/ha)
T_3: FYM @ 8t/ha
T_4: Vermicompost @ 8t/ha
T_5: NPKS (15:20:15:15kg/ha)+ FYM @ 8t/ha
T_6: NPKS (15:20:15:15kg/ha)+vermicompost @ 8t/ha
T_7: Rhizobium culture + PSB
T_8: NPKS (15:20:15:15kg/ha)+ Rhizobium culture+ PSB
T_9: FYM @ 8t/ha+ Rhizobium culture+ PSB
T_{10}: Vermicompost @ 8t/ha+ Rhizobium culture+ PSB

Observations on physiological parameters

Leaf Area per Plant (cm²)

The total number of compound leaves on the plant was counted and calculated starting from 30 days up to 60 days after sowing at a regular interval of 15 days. The leaf area was calculated by leaf area meter in cm^2.

Leaf Area Index (LAI)

The leaf area was calculated at a regular interval of 15 days starting from 30 days up to 60 days after sowing. It was reported with the help of the leaf area meter. The leaf area index was calculated as per the Watson's formula (1952):

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

Net Assimilation Rate (NAR)

The net assimilation rate was measured as the increase in dry matter per unit leaf area per unit time. It was calculated at 30-45 days after sowing and 45-60 days after sowing using the following formula by Blackman (1919):

$$NAR = \frac{W_2 - W_1}{A_2 - A_1} \times \frac{\log A_2 - \log A_1}{T_2 - T_1} \ (mg/cm^2/day)$$

Where
W_2 and W_1 = dry weight of plants at two stages
A_2 and A_1 = leaf area per plant at two stages
T_2 and T_1 = time interval between two observations

Crop Growth Rate (CGR)

An increase in the biomass is an important characteristic of the crop growth. It was calculated by using Watson's formula (1952):

$$CGR = \frac{W_2 - W_1}{P\ (T_2 - T_1)} \ (g/m^2/day)$$

Where
W_2 and W_1 = dry weight of plants at two stages
P = ground area
T_2 and T_1= time interval between two observations

Seed Yield (kg/ha)

Seeds were sun-dried to a standard moisture condition and thereafter the seed yield was recorded in grams from the net plot. The seed yield per plot was then multiplied by a multiplying factor to convert it into seed yield in kg/ha.

Straw Yield (kg)

In order to obtain the straw yield, the weight of the grains per plot was subtracted from the gross weight of the bundle and then it was converted in kg/ha.

Harvest Index (HI)

To calculate the harvest index the following formula was used (Donald, 1962) [5]:

$$HI = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield (grain + straw)}} \times 100$$

Statistical analysis

The data collected from the experiment at various growth stages and harvest were analyzed statistically as described by Panse and Suchatme (1967) [15]. When the treatment differences were significant, standard error (S.E.±) and critical difference (C.D.) were calculated at a 5% probability level and when the treatment differences were not significant, only standard error was worked out.

Results and discussion

Leaf area

Leaf area differed significantly with different treatments (Table 2). The results indicated that all the nutrient management treatments encouraged this parameter up to a significant level as compared to the control treatment in all the observations recorded in 30, 45 and 60 days after sowing. Amongst the fertility treatments, NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha recorded the maximum leaf area 26.24, 36.04 and 80.80, respectively at 30, 45 and 60 days after sowing which was found statistically at par with the rest of the treatments (Fig. 1). The increase in growth resulted in the betterment of leaf area and its sustenance with time scale. The addition of FYM or biofertilizers might have promoted the release of certain growth hormones like IAA, GA3 and cytokinin in the rhizosphere which could have caused greater cell division and cell expansion increasing leaf area (Singh and Singh, 2009) and higher uptake and accumulation of greater amounts of photosynthates leading to increase in overall vegetative growth.

Leaf area index

The leaf area index was influenced significantly due to different fertility treatments at various growth stages of the crop (Table 2). All the integrated nutrient management treatments were found significantly superior over control treatment with respect to LAI. The maximum leaf area index 2.08, 2.11 and 2.23 per m^2 was observed at 30, 45 and 60 days after sowing, respectively in the treatments where the NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha was applied which was significantly superior to the control and was found statistically identical in their influence with the rest of their treatments (Fig. 1). The significant response with FYM application on LAI might be due to the addition of manures that tend to increase the respiration rate metabolism and growth of plants.

Crop growth rate

The different integrated nutrient management treatments brought about significant changes in CGR as compared to the control. The application of NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha recorded significantly higher CGR 3.44 g/m^2/day and 2.89 g/m^2/day at 30-45 and 45-60 days after sowing, respectively as compared to control (Table 2). The treatment application of NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha was found at par with NPKS @ 15:20:15:15 kg/ha +vermicompost @ 8 t/ha, NPKS @ 15:20:15:15 kg/ha + Rhizobium + PSB treatments at 30-45 days after sowing, whereas it was found significantly superior than rest of the treatments at 45-60 days after sowing. The application of nutrient NPKS @ 15:20:15:15 kg/ha alone were found better than organic sources of nutrients applied as FYM @ 8 t/ha, vermicompost @ 8 t/ha, Rhoizobium + PSB however, proved significantly superior to the control treatment (Fig. 1). The INM treatment improved the soil environment which encouraged prolific root characters (root length, root volume and root dry weight) resulting in better absorption of water and nutrients from lower layers and thus resulted in increased growth rate (Hameed Khan, 1990) [9].

Net assimilation rate

All the integrated nutrient management treatments brought about a significant effect on the net assimilation rate as compared to the control treatment (Table 2). Amongst the fertility treatments application of NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha resulted in significantly higher NAR i.e. 2.0047 mg/cm^2/day over control at 30-45 days after sowing which was found at par with the application of NPKS @ 15:20:15:15 kg/ha + vermicompost @ 8 t/ha and at 45-60 days after sowing. The application of NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha recorded maximum NAR 2.0017 mg/cm^2/day which was significantly superior over rest of the treatments including control (Fig. 1). The increase in CGR and NAR at different stages could be the result of an increase in the dry weight and leaf surface area induced by the combined application of inorganic and organic fertilizers (Kuttimani *et al*., 2013) [12].

Grain yield per hectare

The grain yield of lentil was found to influence significantly due to different fertility treatments. The application of NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha, recorded significantly higher grain yield 1072.93 kg/ha than all the treatments followed by NPKS @ 15:20:15:15 kg/ha + vermicompost @ 8 t/ha (1041.50 kg/ha) (Table 3). Both the treatments were found statistically identical to each other. The application of NPKS @ 15:20:15:15 kg/ha along with Rhizobium and PSB gave significantly higher seed yield as compared to FYM @ 8 t/ha + Rhizobium + PSB, vermicompost @ 8 t/ha + Rhizobium + PSB, FYM @ 8 t/ha, vermicompost @ 8 t/ha, and Rhizobium + PSB. However, it was found statistically at par with the application of chemical fertilizer alone NPKS @ 15:20:15:15 kg/ha. The separate application of organic manures and bio-fertilizers also had a significant effect on grain yield over control. The application of FYM @ 8 t/ha along with Rhizobium and PSB recorded a grain yield of 930.42 kg/ha which was found significantly superior to the control and found at par with vermicompost @ 8 t/ha + Rhizobium + PSB, FYM @ 8 t/ha, vermicompost @ 8 t/ha 923.48, 919.18 and 915.62 kg/ha seed yield, respectively. The application of Rhizobium with PSB recorded a seed yield of 870.01 kg/ha, which was found significantly superior than control (Fig. 2). The result indicated that all the organic and inorganic manures and fertilizers applied alone or in combinations increased seed yield significantly than no application.

Straw yield per hectare

The results observed with respect to straw yield of lentil were found to be the same as noticed in the case of grain yield of lentil. The effect of various integrated nutrient management treatments was found significant on straw yield. The application of NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha increased straw yield by 1841.31 kg/ha and found significantly superior than FYM @ 8 t/ha + Rhizobium + PSB, vermicompost @ 8 t/ha + Rhizobium + PSB, FYM @ 8 t/ha, vermicompost @ 8 t/ha, Rhizobium + PSB and control treatments. Further, it was observed that this treatment was found statistically at par with the application of NPKS @ 15:20:15:15 kg/ha + vermicompost @ 8 t/ha and NPKS @ 15:20:15:15 kg/ha. The application of chemical fertilizers alone NPKS @ 15:20:15:15 kg/ha increased straw yield significantly than the control, whereas the application of bio-fertilizers (Rhizobium + PSB) recorded 1618.67 kg/ha straw yield, which was found superior over control.

Harvest index

The result revealed that the effect of various integrated nutrient management treatments on the harvest index was significant. The application of NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha recorded the highest (38.83) harvest index which was found significantly superior than the Rhizobium + PSB and control treatments, whereas this was at par with the rest of the treatments. The effect of chemical fertilizer and organic manure on harvest index alone or in combinations was found significant, whereas the application of bio-fertilizers (Rhizobium + PSB) alone was found non-significant but combined application of Rhizobium + PSB with chemical fertilizers or organic manures was found significantly superior than control (Fig. 2). The significant differences in harvest index under these treatments might be because of the proportionately equally higher grain production over its straw yield as reported by Akhtar *et al.* (2009) [1]. Organic sources like FYM or vermicompost are the storehouse of plant nutrients which might have improved the physicochemical as well as biological properties of the soil to enhance crop growth. On the other hand, the soils applied with only chemical fertilizers are deprived of all these advantages necessary for more accumulation of carbohydrates, and their translocation to the reproductive organs, increased the physiological and productivity parameters of lentil. These results are in conformity with the findings of Giri and Joshi (2010) [7] and Sinha *et al.* (2010) [20].

Table 2: Physiological parameters of lentil as influenced by various treatments

S. No.	Treatments	Leaf area (cm^2)			Leaf area index			CGR ($g/m^2/day$)		NAR ($mg/cm^2/day$)	
		30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS
1.	Control	17.26	27.12	53.82	2.05	2.07	2.16	2.66	2.54	2.0030	2.0009
2.	NPKS @ 15:20:15:15 kg/ha	22.00	31.46	67.02	2.07	2.10	2.21	3.06	2.65	2.0040	2.0010
3.	FYM @ 8 t/ha	20.94	30.08	61.09	2.06	2.10	2.20	2.98	2.60	2.0039	2.0012
4.	Vermicompost @ 8 t/ha	20.99	29.58	60.06	2.06	2.10	2.19	2.91	2.59	2.0037	2.0012
5.	NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha	26.24	36.04	80.80	2.08	2.11	2.23	3.44	2.89	2.0047	2.0017
6.	NPKS @ 15:20:15:15 kg/ha + Vermicompost @ 8 t/ha	24.00	35.70	72.58	2.07	2.11	2.22	3.38	2.85	2.0046	2.0016
7.	Rhizobium + PSB	20.63	29.17	59.66	2.06	2.09	2.19	2.89	2.55	2.0036	2.0015
8.	NPKS @ 15:20:15:15 kg/ha + Rhizobium + PSB	23.21	34.09	71.07	2.07	2.11	2.22	3.18	2.70	2.0041	2.0015
9.	FYM @ 8 t/ha + Rhizobium + PSB	22.73	32.62	68.17	2.07	2.10	2.21	3.09	2.71	2.0039	2.0014
10.	Vermicompost @ 8 t/ha + Rhizobium + PSB	23.00	33.37	70.33	2.07	2.10	2.22	3.16	2.77	2.0040	2.0015
	S.Em ±	0.89	0.41	1.80	0.003	0.005	0.10	0.05	0.031	0.0002	0.0001
	C.D. at 5%	2.58	1.19	5.22	0.009	0.014	0.028	0.27	0.091	0.0006	0.0002

Table 3: Grain yield, straw yield and harvest index of lentil as influenced by various treatments

S. No.	Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index
1.	Control	746.92	1451.94	35.98
2.	NPKS @ 15:20:15:15 kg/ha	985.64	1730.26	38.27
3.	FYM @ 8 t/ha	919.18	1673.35	37.44
4.	Vermicompost @ 8 t/ha	915.62	1630.67	37.92
5.	NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha	1072.93	1841.31	38.83
6.	NPKS @ 15:20:15:15 kg/ha + Vermicompost @ 8 t/ha	1041.50	1802.62	38.74
7.	Rhizobium + PSB	870.01	1618.67	36.93
8.	NPKS @ 15:20:15:15 kg/ha + Rhizobium + PSB	1011.22	1760.45	38.46
9.	FYM @ 8 t/ha + Rhizobium + PSB	930.42	1713.91	37.20
10.	Vermicompost @ 8 t/ha + Rhizobium + PSB	923.48	1695.33	37.27
	S.Em ±	20.07	42.17	0.62
	C.D. at 5%	27.98	121.78	1.81

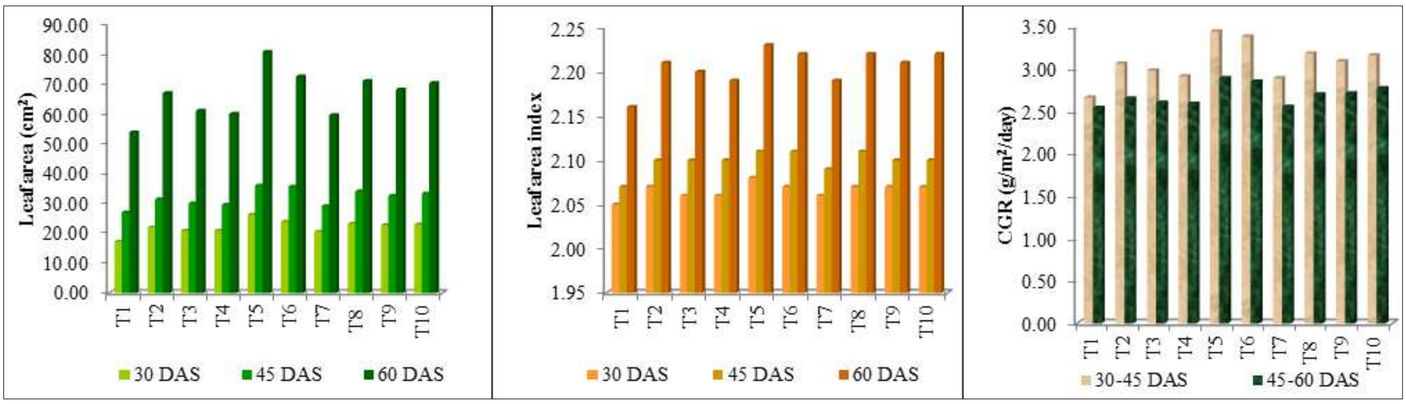

Fig 1: Physiological parameters of lentil as influenced by various treatments

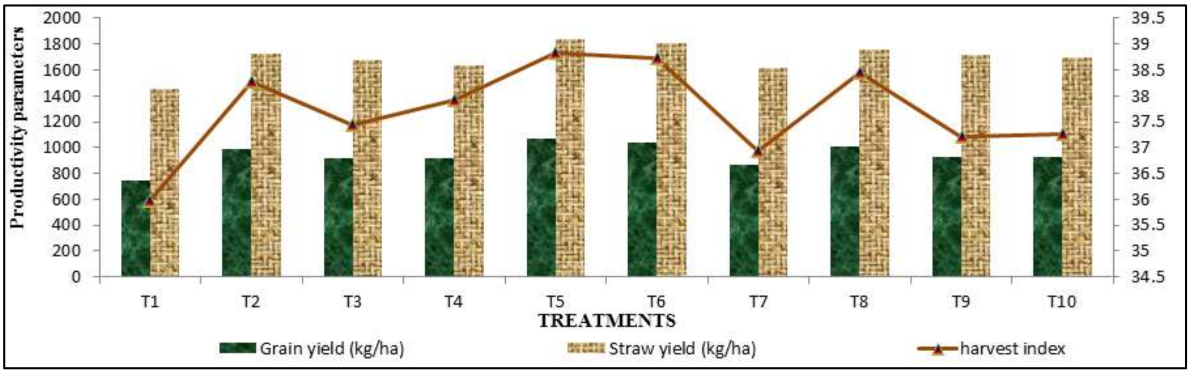

Fig 2: Productivity parameters of lentil as influenced by various treatments

Conclusions

It can be concluded that supplementing the recommended dose of nutrients (NPKS @ 15:20:15:15 kg/ha) with FYM @ 8 t/ha or vermicompost @ 8 t/ha or Rhizobium + PSB inoculation help in obtaining high grain yields and net returns in lentil. Maximum leaf area, leaf area index, crop growth rate and net assimilation rate of lentil were obtained with the use of NPKS @ 15:20:15:15 kg/ha + FYM @ 8 t/ha followed by NPKS @ 15:20:15:15 kg/ha + vermicompost @ 8 t/ha, resulting in higher grain yields of 1072.93 kg/ha and 1041.50 kg/ha, respectively. The study highlights the role of organic fertilizers in lentil, which could play an important role in sustainable agriculture.

References

1. Akhtar MS, Siddiqui ZA. Effects of phosphate solubilizing microorganisms and Rhizobium sp. on the growth, nodulation, yield and root-rot disease complex of chickpea under field condition. African J. Biotechnol 2009;8(15):3489-3496.
2. Arif M, Ali K, Jan MT, Shah Z, Jones DL, Quilliam RS. Integration of biochar with animal manure and nitrogen for improving maize yields and soil properties in calcareous semi-arid agroecosystems. Field Crops Res 2016;195:28-35.
3. Blackman VH. The compound interest law and plant growth. Ann. Bot 1919;33:353-356.
4. Chandra RD. Influence of different levels of Rhizobium inoculation and phosphorus on nodulation, dry matter production and yield of lentil. Legume Research 1991;14(3):145-146
5. Donald CM. In search of yield. J Aust. Inst. Agric. Sci 1962;28:171.
6. Gangwar K, Singh K, Sharma S, Tomar O. Alternative tillage and crop residue management in wheat after rice in sandy loam soils of Indo-Gangetic plains. Soil and Tillage Res 2006;88:242-252.
7. Giri N, Joshi NC. Growth and yield response of chick pea (Cicer arietinum) to seed inoculation with Rhizobium sp. Nature & Sci 2010;8(9):232-236.
8. Güereña DT, Kimetu J, Riha S, Neufeldt H, Lehmann J. Maize productivity dynamics in response to mineral nutrient additions and legacy organic soil inputs of contrasting quality. Field Crops Res 2016;188:113-120.
9. Hameed Khan A. Studies in urea hydrolysis and ammonia volatilization from soil. Ph.D Thesis, Tamil Nadu Agric. Univ., Coimbatore; 1990.
10. Hepperly P, Lotter D, Ulsh CZ, Seidel R, Reider C. Compost, manure and synthetic fertilizer influences crop yields, soil properties, nitrate leaching and crop nutrient content. Compost Sci. Util. 2009;17:117-126.
11. Jones DL, Healey JR. Organic amendments for remediation: Putting waste to good use. Elements 2010;6:369–374.
12. Kuttimani R, Velayudham K, Somasundaram E, Jagath Jothi N. Effect of integrated nutrient management on corm and root growth and physiological parameters of banana. International Journal of Advanced Research 2013;1(8):46-55.
13. Meena BS, Ram B. Effect of integrated nutrient management on productivity, soil fertility and economics of blackgram (Vigna mungo) varieties under rainfed condition. Legume Research 2016;39:268-273.
14. Niri HH, Tobeh A, Gholipouri A, Zakaria RA, Mostafaei H, Jamaati-e-Somarin S. Effect of nitrogen and phosphorus on yield and protein content of lentil in dryland condition. American-Eurasian Journal of Agricultural and Environmental Science 2010;8:185-188.
15. Panse VG, Sukhatme PV. "Statistical Methods for Agricultural Workers," 2nd Edition, Indian Council of Agricultural Research, New Delhi, 1967.
16. Rasheed M, Jilani G, Shah IA, Najeeb U, Iqbal T. Improved lentil production by utilizing genetic variability in response to phosphorus fertilization. Acta Agriculturae Scandinavica, Section B: Plant Soil Science 2010;60:485-493.
17. Sarkar S, Singh SR, Singh RP. The effect of organic and inorganic fertilizers on soil physical condition and the productivity of a rice-lentil cropping sequence in India. Journal of Agricultural Science 2003;140:419-425.
18. Singh N, Singh G, Khanna V. Growth of lentil (*Lens culinaris* Medikus) as influenced by phosphorus, Rhizobium and plant growth promoting rhizobacteria. Indian Journal of Agricultural Research 2016;50:567-572.
19. Singh A, Singh JN. Effect of biofertilizers and bioregulators on growth, yield and nutrient status of strawberry cv Sweet Charlie. Indian Journal of Horticulture 2009;66(2):220-224.
20. Sinha J, Biswas CK, Ghosh A, Saha A. Efficacy of vermicompost against fertilizers on Cicer and Pisum and on population diversity of N2 fixing bacteria. J. Environ. Bio 2010;31(3):287-292.
21. Watson DJ. The physiological basis variation in yield. Advance Agron 1952;4:101-145.