**Bulletin of Environment, Pharmacology and Life Sciences**
Bull. Env. Pharmacol. Life Sci., Vol 6[4] March 2017: 55-62

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804
NAAS Rating 4.95

**ORIGINAL ARTICLE** **OPEN ACCESS**

# Integrated Nutrient Management In Lentil (*Lens culinaris* Medikus) In Red And Lateritic Soils Of West Bengal

**Gayatri Sahu[1], Nitin Chatterjee and Goutam Kumar Ghosh***
*Professor (Soil Science and Agricultural Chemistry), [1]M Sc. Scholar, Institute of Agriculture, Visva- Bharati University, Sriniketan – 731 236, West Bengal, India
Correspondence Email: gayatrisahu27@gmail.com

**ABSTRACT**
*A field experiment was conducted on lentil during Rabi season of 2015 in red and lateritic soils of West Bengal at the Agricultural Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan to study the effect of combined application of fertilizer, micronutrients and biofertilizers on yield, nutrient uptake, soil fertility status along with microbial population in Lentil. The experiment was laid out in randomized block design. Combined application of inorganic nutrients along with micronutrients ($N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{1.0}$) recorded highest seed yield (6.98 q $ha^{-1}$), stalk yield (19.53 q $ha^{-1}$), biological yield (26.51 q $ha^{-1}$) and harvest index (26.35%) as compared to inorganically treated nutrients followed by biofertilizer inoculated treatments. The nitrogen uptake was higher in treatment consists $N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{1.0}$. The phosphorus and potassium uptake was influenced by combined application of inorganic fertilizers along with biofertilizers ($N_{15}P_{20}K_{20}$+Rhizobium+PSB). Sulfur uptake was higher in case of micronutrients treated plots along with sulphur and macronutrients followed by biofertilizer inoculated treatments. Highest crude protein content and protein yield in seed of lentil was recorded due to application of sulphur along with micro and macronutrients ($N_{15}P_{40}K_0Zn_{21}S_{17}Mo_{2.0}$). Seed inoculation of Rhizobium and PSB significantly built up their number in soil.*
***Keywords:*** *Lentil, Integrated Nutrient Management, Macro and Micronutrients, Sulphur, Rhizobium, PSB, Yield*

Received 01.01.2017 Revised 15.02.2017 Accepted 18.02.2017

## INTRODUCTION

The post green revolution scenario of Indian agriculture encompasses many problems such as stagnation or even decline in production and productivity growth rates of major crops, deterioration of soil fertility, decline in factor productivity, low diversity of production systems and increasing cost of production. These constraints have cropped-up partially as a result of continuous cropping without proper nutrient management and indiscriminate use of agrochemicals on soil and crops. Indiscriminate use of high analysis chemical fertilizers resulted in the deficiency of nutrients other than the applied and disturbs the natural equilibrium of nutrient elements in soils. The problems of micronutrients also generally crops up with the use of high analysis chemical fertilizers having one or two nutrient elements [1]. The decline in productivity of intensive cropping systems over the years was associated with deficiencies of secondary and micronutrients [2]. Sustainability of crop production is not a viable proposition either through use of organic manures or chemical fertilizers alone [3]. Use of chemical fertilizers alone increase the crop yields in the initial year adversely affected the sustainability at a later stage. Furthermore, the chemical fertilizers are in short supply, derived from non-renewable sources of energy and are costly. Under these constraints, bioinoculants are the route to alternative strategy and many workers reported the beneficial effects of integrating biofertilizers on crop growth, yield and maintenance of soil fertility [4].

Pulses form an integral part of the vegetarian diet and the cheapest source of protein for the resource of poor farmers of the Indian sub-continent. The pulses are also known to increase productivity of soil through fixation of nitrogen from atmosphere, addition of biomass to soil and secretion of growth promoting substances. Lentil contributes about 6 per cent in total pulse area as well as production of India. Lentil (*Lens culinaris* Medikus) is an important grain legume in Asia. It occupies an important position in this region. India is the world's major lentil producing country, followed by Canada and Turkey, which collectively account for 68% of global production (FAO 2008). It is an important source of protein and several essential micronutrients. It synthesizes N in symbiosis with *Rhizobium* and enriches the soil. It improves the fertility status of soil through atmospheric N fixation. Among different states in India, Uttar Pradesh rank first, Bihar ranks second and Madhya Pradesh rank third in lentil production. Out of total pulses, lentil ranks fourth in acreage and fifth in production and third in productivity in West Bengal.

However, there is a great possibility to increase lentil production by cultivating HYV with balanced fertilization including micronutrient. Micronutrients play an important role in increasing yield of pulses through their effect on the plant itself and on the Nitrogen fixing by symbiotic process. Deficiencies of these nutrients have been very pronounced under multiple cropping systems due to excess removal by HYV of crops and hence their exogenous supplies are urgently required. Zinc and Boron deficiency is widespread in the country; much observed in wetland rice soils, light textured soils and calcareous [5]

## MATERIALS AND METHODS

A field experiment was conducted on sesame during rabi season of 2015 in red and lateritic soils of West Bengal at the Agricultural Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan. The experimental farm was situated at 23°39ʹ N latitude and 87°42ʹ E longitude with an average altitude of 58.9 m above the mean sea level under sub humid semi-arid region of West Bengal. The soil was acidic (pH 4.35), low in organic carbon (0.32%), available nitrogen (160 kg $ha^{-1}$), available phosphorus (15.92kg $ha^{-1}$), available potassium (72 kg $ha^{-1}$), available sulphur (11.23 kg $ha^{-1}$). The experiment was laid out in randomized block design with 15 treatments. As per the treatments specification, fertilizers were applied in the form of urea, Diammonium phosphate (DAP), Murate of potash (MOP) for the source of nitrogen, phosphorus and potassium respectively. Magnesium sulphate (26.63% S) was used for the source of sulphur. In the cases of micronutrients Boric acid (17% B), Zinc Sulphate Heptahydrate (21% Z), Ammonium molybdate (54% Mo) are used for the source of boron, zinc and molybdenum. The available nutrient status of soil, total uptake of nutrients, grain yield, stover yield, protein content and protein yield was calculated. The soil samples were analyzed following standard procedures. Available sulphur in the soil was extracted using 0.15% $CaCl_2$ solution. The total sulphur in the soil was extracted by perchloric acid ($HClO_4$) digestion. Sulfur content in the digest of plant and soil extract was determined using turbidimetric method of Chesnin and Yien. The amount of seed nitrogen content was estimated as per Jackson and expressed the concentration in percentage. Crude protein was determined by multiplying percentage of nitrogen content in seeds of lentil with a factor of 6.25. The data collected from the experiment at different growth stages was subjected to statistical analysis as described by Gomez and Gomez.

## RESULTS AND DISCUSSION

### Available N, P, K and S status in soil of lentil

Analysis of the data of available nitrogen, phosphorous, potassium and sulphur content in soil is presented in Table 1. Balanced fertilization improved the available nitrogen in all the treatments over its initial value i.e 160kg $ha^{-1}$. Integrated application of inorganic fertilizer and biofertilizer was more effective in increasing the soil available N. Highest value was observed in $T_{11}$ over control due to seed inoculation with biofertilizer, which was exerted a significant effect on available nitrogen content in soil.The available phosphorus content ranged from 20.37 kg $ha^{-1}$ to 43.62 kg $ha^{-1}$ after harvesting of lentil with minimum in control and maximum in $T_{11}$, which was treated by biofertilizer along with other synthetic fertilizer.

**Table 1. Effect of INM treatments on available NPKS status of lentil**

| Treatments | 2014-2015 | | | |
|---|---|---|---|---|
| | Available N | Available P | Available K | Available S |
| | (kg ha$^{-1}$) | | | |
| $T_1$- Control | 183.98 | 20.37 | 66.19 | 17.64 |
| $T_2$-$N_{15}P_{20}K_0$ | 192.34 | 22.46 | 59.62 | 21.17 |
| $T_3$-$N_{15}P_{40}K_0$ | 200.70 | 29.77 | 57.72 | 21.00 |
| $T_4$-$N_{15}P_{20}K_{20}$ | 234.15 | 21.68 | 43.75 | 21.84 |
| $T_5$-$N_{15}P_{40}K_{20}$ | 225.79 | 30.82 | 46.97 | 20.83 |
| $T_6$-$N_{15}P_{20}K_{40}$ | 242.52 | 22.72 | 45.92 | 20.33 |
| $T_7$-$N_{15}P_{40}K_{40}$ | 250.88 | 33.43 | 45.58 | 22.85 |
| $T_8$-$N_{15}P_{20}K_{60}$ | 225.79 | 24.03 | 44.31 | 22.68 |
| $T_9$-$N_{15}P_{40}K_{60}$ | 242.52 | 36.04 | 45.99 | 21.84 |
| $T_{10}$-$N_{15}P_{20}K_{20}$+*Rhizobium* | 267.61 | 39.18 | 47.34 | 22.68 |
| $T_{11}$-$N_{15}P_{20}K_{20}$+*Rhizobium*+PSB | 284.33 | 43.62 | 48.98 | 23.35 |
| $T_{12}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}$ | 259.24 | 28.73 | 48.72 | 24.19 |
| $T_{13}$-$N_{15}P_{40}K_0Zn_{21}S_{17}Mo_{2.0}$ | 259.24 | 31.86 | 47.38 | 25.20 |
| $T_{14}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{0.5}$ | 250.88 | 33.95 | 47.49 | 24.02 |
| $T_{15}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{1.0}$ | 267.61 | 32.91 | 48.35 | 24.86 |
| SEm(±) | 14.100 | 5.007 | 5.028 | 1.490 |
| CD(P=0.05) | 43.443 | 15.428 | 15.492 | 4.591 |
| CV% | 11.57 | 32.65 | 19.89 | 13.11 |
| RBD(0.05) | S | NS | NS | NS |

It was also observed that by addition of phosphatic fertilizer @ 40 kg ha$^{-1}$ significantly increased the content of available phosphorus than the level of phosphorus @ 20 kg ha$^{-1}$. It is interesting to note that significantly higher available potassium content was recorded in plots which received no phosphorus. This might be due to the reason that phosphorus is responsible for potassium metabolism. The seed inoculation exerted significant effect on available potassium content in soil. Uninoculated control recorded higher available potassium content in soil as compared to all other treatments. Available sulphur content in soil was increased by adding nitrogenous fertilizer over control. The range of available sulphur varied between 17.64 to 25.20 kg ha$^{-1}$. Highest value was observed in $T_{13}$ due to application of higher level of sulphatic fertilizer @17 kg ha$^{-1}$. Result obtained from other treatments like $T_{12}$, $T_{14}$, $T_{15}$ are at par which was treated by sulphur.

**Effect of INM treatments on lentil yield**

Analysis of data about effect of treatments on the yield of lentil is presented in Table 2. The table consists the seed, stalk and biological yield of lentil along with harvest index.

**Table 2. Effect of INM treatments on Lentil yield**

| Treatments | 2014-2015 | | | |
|---|---|---|---|---|
| | Seed Yield | Stalk Yield | Biological Yield | Harvest Index (%) |
| | q ha$^{-1}$ | | | |
| $T_1$- Control | 4.09 | 16.10 | 20.19 | 20.26 |
| $T_2$-$N_{15}P_{20}K_0$ | 4.48 | 16.56 | 21.04 | 21.29 |
| $T_3$-$N_{15}P_{40}K_0$ | 5.17 | 17.17 | 22.34 | 23.13 |
| $T_4$-$N_{15}P_{20}K_{20}$ | 5.31 | 17.23 | 22.54 | 23.55 |
| $T_5$-$N_{15}P_{40}K_{20}$ | 5.42 | 17.75 | 23.17 | 23.38 |
| $T_6$-$N_{15}P_{20}K_{40}$ | 5.94 | 18.03 | 23.97 | 24.78 |
| $T_7$-$N_{15}P_{40}K_{40}$ | 5.96 | 17.89 | 23.85 | 24.92 |
| $T_8$-$N_{15}P_{20}K_{60}$ | 6.23 | 18.04 | 24.27 | 25.65 |
| $T_9$-$N_{15}P_{40}K_{60}$ | 6.34 | 18.32 | 24.66 | 25.73 |
| $T_{10}$-$N_{15}P_{20}K_{20}$+*Rhizobium* | 6.43 | 18.27 | 24.7 | 26.03 |
| $T_{11}$-$N_{15}P_{20}K_{20}$+*Rhizobium*+PSB | 6.50 | 18.67 | 25.17 | 25.80 |
| $T_{12}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}$ | 6.57 | 19.22 | 25.79 | 25.47 |
| $T_{13}$-$N_{15}P_{40}K_0Zn_{21}S_{17}Mo_{2.0}$ | 6.68 | 19.28 | 25.96 | 25.73 |
| $T_{14}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{0.5}$ | 6.86 | 19.20 | 26.06 | 26.33 |
| $T_{15}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{1.0}$ | 6.98 | 19.53 | 26.51 | 26.35 |
| SEm(±) | 0.081 | 0.107 | 0.113 | 0.311 |
| CD(P=0.05) | 0.251 | 0.331 | 0.349 | 0.959 |
| CV% | 2.70 | 1.16 | 0.92 | 2.49 |
| RBD(0.05) | S | S | S | S |

Seed yield was affected significantly by integrated application of fertilizer in different treatments over control. Combined application of inorganic nutrients along with micronutrients increased seed yield as compared to only inorganically treated nutrients. So combined application of macro and micronutrients along with sulphur plays a great role to increase the seed yield. The highest seed yield (6.98 q $ha^{-1}$) was observed in $T_{15}$ and lowest value (4.09 q ha-1) was observed in control. Seed inoculation of *Rhizobium* + PSB @ 60 g $kg^{-1}$ seed recorded significantly higher seed yield as compared to uninoculated control except micronutrient treated plots. Dual application of biofertilizer gave more yield than single application of biofertilizer. This result is in conformity with the findings of [6, 7]

Improvement of yield due to combined application of inorganic fertilizer and biofertilizer might be attributed to controlled release of nutrients in soil through mineralization of biofertilizer which might have facilitated better crop growth [8]. In case of $T_{15}$ ($N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{1.0}$) i.e. integrated use of fertilizer was done by combined application of micro and macronutrients. So it was observed that micronutrients play a greater role to increase the yield of crop rather than macronutrients.

Like seed yield, stalk yield was significantly affected by different treatments under consideration. In case of stalk yield, highest yield (19.53 q $ha^{-1}$) was recorded in $T_{15}$ ($N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{1.0}$) followed by $T_{13}$ ($N_{15}P_{40}K_0Zn_{21}S_{17}Mo_{2.0}$) 19.28 q $ha^{-1}$. The stalk yield of $T_{12}$ and $T_{14}$ treatments were almost same. Lowest stalk yield (16.10 q $ha^{-1}$) was found in control. In this case also combined application of micronutrients along with macronutrients and sulphur gave higher yield as compared to all other treatments.

Depending upon stalk yield and seed yield the biological yield was calculated. The biological yield was found highest (26.51 q $ha^{-1}$) in $T_{15}$ followed by $T_{14}$ (26.06 $qha^{-1}$) and lowest value was observed in control i.e. 20.19 q $ha^{-1}$.

Harvest index was also calculated depending upon the seed yield and biological yield. The ranges of harvest index observed in case of lentil ranges from 20.26-26.35. The highest harvest index (26.35) was found in $T_{15}$ followed by $T_{14}$ (26.33) and lowest value was observed in control.

**Uptake of nutrients (NPKS) by lentil**

Analysis of the data about uptake of nutrients (NPKS) by lentil is shown in Table 3.

Results indicate that N uptake in lentil increased with integration of micronutrients with macronutrients along with sulphur. Nitrogen uptake is higher in stalk than seed because yield of stalk was more than that of seed. Uptake of N by seed ranges between 6.94 to 19.33 kg $ha^{-1}$. The highest N uptake was observed in $T_{15}$ due to integrated application of micronutrients with macronutrients along with sulphur followed by $T_{13}$ and lowest value was observed in control plot. The uptake of N by stalk ranges between 18.03 to 25.56 kg $ha^{-1}$.The highest uptakes was observed in $T_{12}$ and lowest value was observed in control plot. Depending upon the stalk uptake and seed uptake total uptake of lentil was summed up. The total N uptake ranged between 24.97to 44.09 kg $ha^{-1}$. The highest value of total N uptake was observed in $T_{15}$ (i.e. 44.09 $kgha^{-1}$) followed by $T_{12}$ and $T_{13}$, lowest value was observed in control plot. The higher N uptake with biofertilizers and organic manure might be attributed to solubilisation of native nutrients, chelating of complex form of intermediate organic molecules produced during decomposition of added organic manures, their mobilization and accumulation of different nutrients in plant parts. The results are in agreement with findings of [9]. Seed inoculation of *Rhizobium* + PSB @ 60 g $kg^{-1}$ seed recorded significantly higher nitrogen uptake in stalk as compared to uninoculated control except micronutrients treated plots. This result is in conformity with the findings of [10]. Phosphorus uptake in lentil was lower as compared to nitrogen and potassium uptake. Like nitrogen the uptake by stalk is higher than seed. It was also influenced by combined application of inorganic fertilizers along with biofertilizers. Almost all the INM treatments gave significantly higher P uptake by lentil over control. Phosphorus uptake by seed ranges between 2.56 to 5.28 kg $ha^{-1}$.The highest uptake was found in $T_{11}$ (i.e. 5.28 kg P $ha^{-1}$) due to dual application of biofertilizer (*Rhizobium* and PSB) along with inorganic fertilizer followed by $T_{15}$. Similarly in case of stalk uptake of P ranges between 5.19 to 8.92 kg $ha^{-1}$. The highest uptake was found in $T_{11}$ followed by $T_{10}$ (i.e. 8.58 kg P $ha^{-1}$). It was also observed that the total uptake of P ranges between 7.76-14.20 $kgha^{-1}$. The highest uptake of P was found in case of $T_{11}$ followed by $T_{10}$ (i.e. 13.57 kg P $ha^{-1}$). In all three cases lowest value was observed in control plot. Seed inoculation increased phosphorus uptake in grain significantly. Seed inoculation of *Rhizobium* + PSB @ 60 g $kg^{-1}$ seed recorded significantly higher phosphorus uptake in grain as compared to other treatments. This might be due to higher dry matter production. The above findings, in general reveal that phosphorus uptake by stalk, grain and total uptake increased by application of biofertilizers inoculation.

Table 3: Uptake of nutrients by llentil

| Treatments | 2014-15 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nutrient uptake(kg/ha) | | | | | | | | | | | |
| | N | | | P | | | K | | | S | | |
| | Seed | Stalk | Total | Seed | Stalk | Total | Seed | Stalk | Total | Seed | Stalk | Total |
| $T_1$- Control | 6.94 | 18.03 | 24.97 | 2.56 | 5.19 | 7.76 | 4.7 | 19.48 | 24.18 | 0.56 | 8.84 | 9.4 |
| $T_2$-$N_{15}P_{20}K_0$ | 10.08 | 20.09 | 30.17 | 3 | 5.78 | 8.78 | 5.39 | 21.48 | 26.86 | 0.97 | 8.77 | 9.74 |
| $T_3$-$N_{15}P_{40}K_0$ | 11.39 | 22.12 | 33.5 | 3.77 | 6.73 | 10.5 | 6.31 | 21.37 | 27.69 | 1.26 | 9.96 | 11.22 |
| $T_4$-$N_{15}P_{20}K_{20}$ | 12.19 | 18.64 | 30.83 | 3.53 | 6.7 | 10.23 | 6.1 | 21.56 | 27.66 | 1.1 | 12.25 | 13.35 |
| $T_5$-$N_{15}P_{40}K_{20}$ | 12.34 | 22.21 | 34.54 | 4.02 | 7.67 | 11.69 | 6.95 | 22.66 | 29.6 | 1.23 | 12.25 | 13.48 |
| $T_6$-$N_{15}P_{20}K_{40}$ | 14.01 | 22.54 | 36.56 | 4.34 | 6.73 | 11.06 | 7.75 | 23.45 | 31.2 | 1.47 | 12.62 | 14.09 |
| $T_7$-$N_{15}P_{40}K_{40}$ | 13.84 | 22.36 | 36.21 | 4.22 | 6.48 | 10.7 | 7.7 | 23.83 | 31.54 | 1.68 | 13.32 | 15 |
| $T_8$-$N_{15}P_{20}K_{60}$ | 14.41 | 22.23 | 36.63 | 4.61 | 6.68 | 11.29 | 7.61 | 23.04 | 30.65 | 1.25 | 12.07 | 13.32 |
| $T_9$-$N_{15}P_{40}K_{60}$ | 14.33 | 18.81 | 33.14 | 4.49 | 6.92 | 11.42 | 8.51 | 23.62 | 32.14 | 1.48 | 13.85 | 15.33 |
| $T_{10}$-$N_{15}P_{20}K_{20}$+*Rhizobium* | 15.43 | 23.53 | 38.96 | 4.99 | 8.58 | 13.57 | 8.75 | 24.11 | 32.86 | 2.66 | 10.28 | 12.94 |
| $T_{11}$-$N_{15}P_{20}K_{20}$+*Rhizobium*+PSB | 15.79 | 22.59 | 38.37 | 5.28 | 8.92 | 14.2 | 7.99 | 26.89 | 34.88 | 2.79 | 11.92 | 14.71 |
| $T_{12}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}$ | 17.76 | 25.56 | 43.32 | 4.86 | 6.84 | 11.69 | 6.91 | 24.44 | 31.35 | 2.45 | 13.48 | 15.93 |
| $T_{13}$-$N_{15}P_{40}K_0Zn_{21}S_{17}Mo_{2.0}$ | 19.19 | 24.1 | 43.29 | 4.94 | 7.55 | 12.5 | 8.63 | 24.81 | 33.44 | 3.05 | 13.44 | 16.49 |
| $T_{14}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{0.5}$ | 18.84 | 21.84 | 40.69 | 4.99 | 6.96 | 11.95 | 8.32 | 24.02 | 32.33 | 2.25 | 12.5 | 14.75 |
| $T_{15}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{1.0}$ | 19.33 | 24.76 | 44.09 | 5.23 | 7.23 | 12.46 | 8.45 | 25.84 | 34.29 | 2.42 | 20.72 | 23.14 |
| SEm(±) | 0.315 | 1.037 | 1.144 | 0.128 | 0.44 | 0.452 | 0.118 | 0.334 | 0.308 | 0.113 | 0.506 | 0.55 |
| CD(P=0.05) | 0.972 | 3.197 | 3.526 | 0.395 | 1.356 | 1.394 | 0.364 | 1.029 | 0.95 | 0.348 | 1.561 | 1.695 |
| CV% | 4.3 | 9.27 | 6.18 | 5.83 | 12.35 | 7.84 | 3.16 | 2.8 | 1.97 | 12.53 | 8.01 | 7.6 |
| RBD(0.05) | S | NS | S | S | S | S | S | S | S | S | S | S |

Potassium uptake was found significantly higher in almost all INM treatments as compared to control. In case of potassium the uptake by stalk was more than seed. The uptake of K in seed ranged between 4.70 to 8.75 kg $ha^{-1}$. The highest uptake was found in $T_{10}$ due to application of biofertilizer along with inorganic fertilizer but in this case *Rhizobium* inoculated treatment ($T_{10}$) gave higher yield than *Rhizobium* and PSB inoculated treatment ($T_{11}$). Potassium uptake by stalk ranged between 19.48 to 26.89 kg $ha^{-1}$. The highest K uptake was found in $T_{11}$ followed by $T_{15}$ (i.e. 25.84 kg $ha^{-1}$). Similarly the range of total uptake varied between 24.18 to 34.88 kg $ha^{-1}$. In this case also highest yield was found in $T_{11}$ followed by $T_{15}$. In all three cases lowest value was observed in control plots. The increased uptake by K in lentil may be ascribed to the release of K from the K bearing minerals by complexing agents and organic acids produced during decomposition of organic sources.

Sulphur uptake by lentil was also similar with all cases of nutrient uptake. It was observed that the sulphur uptake was also higher in case of stalk than seed and also the uptake of sulphur is higher in case of micronutrients treated plots along with sulphur and macronutrients as compared to all other treatments. The sulphur uptake in case of seed varied between 0.56 to 3.05 kg $ha^{-1}$. The highest S uptake was found in case of $T_{13}$ which was treated by sulphur sources @17kg S $ha^{-1}$ along with micro and macronutrients followed by biofertilizers inoculated treatment i.e. $T_{11}$ and lowest value was observed in control plot. In case of stalk, the S uptake ranged between 8.77-20.72 kg $ha^{-1}$. The highest S uptake was found in $T_{15}$. Lowest S uptake was observed in $T_2$ instead of control, it may be due to variability in research plot. In case of total uptake S ranges varied between 9.40-23.14 kg $ha^{-1}$. In this case highest yield was also observed in $T_{15}$ followed by $T_{13}$ and lowest value was observed in control plot. Similar findings were also reported by [11] who found uptake of sulphur was more in case of integrated use of biofertilizers along with inorganic fertilizer as compared to control.

**Crude protein content and protein yield of lentil**

The data related to crude protein content and protein yield of lentil presented in table 4 indicated that the trend in protein content was similar to that of nitrogen uptake by lentil.

**Table 4. Crude protein content and protein yield of lentil**

| Treatments | 2014-15 | |
|---|---|---|
| | Protein content (%) | Protein Yield (kg/ha) |
| $T_1$- Control | 10.62 | 43.40 |
| $T_2$-$N_{15}P_{20}K_0$ | 14.12 | 62.99 |
| $T_3$-$N_{15}P_{40}K_0$ | 13.77 | 71.16 |
| $T_4$-$N_{15}P_{20}K_{20}$ | 14.35 | 76.16 |
| $T_5$-$N_{15}P_{40}K_{20}$ | 14.23 | 77.12 |
| $T_6$-$N_{15}P_{20}K_{40}$ | 14.54 | 87.57 |
| $T_7$-$N_{15}P_{40}K_{40}$ | 14.58 | 86.52 |
| $T_8$-$N_{15}P_{20}K_{60}$ | 14.47 | 90.06 |
| $T_9$-$N_{15}P_{40}K_{60}$ | 14.12 | 89.56 |
| $T_{10}$-$N_{15}P_{20}K_{20}$+*Rhizobium* | 15.00 | 96.46 |
| $T_{11}$-$N_{15}P_{20}K_{20}$+*Rhizobium*+PSB | 15.19 | 98.66 |
| $T_{12}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}$ | 16.92 | 107.53 |
| $T_{13}$-$N_{15}P_{40}K_0Zn_{21}S_{17}Mo_{2.0}$ | 17.96 | 119.94 |
| $T_{14}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{0.5}$ | 17.17 | 117.77 |
| $T_{15}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{1.0}$ | 17.31 | 120.78 |
| SEm(±) | 0.352 | 2.026 |
| CD(P=0.05) | 1.084 | 6.243 |
| CV% | 4.62 | 4.43 |
| RBD(0.05) | S | S |

It was observed that the range of protein content ranged between 10.62 to 17.96%. The highest value of protein content in lentil 17.96% was associated with $T_{13}$ followed by $T_{15}$ i.e. 17.31% and lowest value i.e. 10.62% was associated with control plot. $T_{13}$ gave highest yield due to application of sulphur@17kgha$^{-1}$ along with micro and macronutrients. So sulphur plays a major role to increase the protein content along with nitrogen. After micronutrient and sulphur treated plots higher protein value was observed in biofertilizers inoculated treatments. Thus biofertilizers has played a great role to increase the protein content because it adds nitrogen in soil and other growth promoting substances. Protein yield was calculated depending upon the protein content and seed yield of lentil. The highest protein yield was obtained in $T_{15}$ i.e.120.78kg $ha^{-1}$ followed by $T_{13}$ i.e. 119.94 kg $ha^{-1}$ but in case of protein content $T_{13}$ i.e. 120.78 kg $ha^{-1}$ followed by $T_{15}$. As the seed yield of $T_{15}$ was more than $T_{13}$, the protein yield was more in $T_{15}$. Lowest yield was obtained in control. The improvement of protein content and protein yield of lentil due to integrated nutrient management is in agreement with the findings of [12].

**Microbial population in soil after harvesting of lentil**

Analysis of the data of microbial population in soil after harvesting of lentil is presented in Table 5. The microbial population mainly includes Nitrogen Fixing Bacteria (NFB) i.e. *Rhizobium* and Phosphorus Solubilising Bacteria (PSB).

The population of nitrogen fixing bacteria depends largely on the concentrations of different exchangeable bases and also on some micronutrients. Number of nitrogen fixing bacteria i.e. *Rhizobium* in soil is increased due to inoculation of biofertilizers with seed. The seed inoculation exerted significant effect on number of nitrogen fixing bacteria in soil. Seed inoculation of *Rhizobium* + PSB @ 60 g $kg^{-1}$ seed i.e. $T_{11}$ recorded significantly higher number of nitrogen fixing bacteria in soil as compared to other treatments but *at par* with seed inoculation of *Rhizobium* @ 60 g $kg^{-1}$ seed i.e. $T_{10}$.

Significant variation was noticed in phosphate solubilizers population in soil due to different phosphorus levels. Among these phosphorus 40 kg $ha^{-1}$ recorded significantly higher phosphate solubilizers population in soil as compared to other treatments. The phosphate solubilizer inoculated treatments showed significant increase in phosphate solubilizers population over no seed inoculated and *Rhizobium* inoculated treatments. It is a well-established fact that there will be higher metabolic activity and nutrient concentration in the rhizosphere region[13]. The plant root primarily determines the nature and extent of rhizosphere microflora. Hence, any factor affecting root growth or metabolism will result in quantitative changes in the rhizosphere microbial population [14]. In the present investigation, it was seen that the population of phosphate solubilizer in soil was significantly increased due to seed inoculation of PSB over uninoculated treatments. These results are in agreement with the findings of [15] in potato. Even the uninoculated plots showed the presence of phosphate solubilizers. Seed inoculation of *Rhizobium* + PSB @ 60 g $kg^{-1}$ seed was *at par* with Seed inoculation of PSB @ 60 g $kg^{-1}$ seed.

| Treatments | 2014-15 | | | |
|---|---|---|---|---|
| | Initial value | | *Rhizobium* (No.× $10^6$cfu $g^{-1}$) | PSB (No.× $10^6$cfu $g^{-1}$) |
| | *Rhizobium* | PSB | | |
| $T_1$- Control | | | 6.35 | 4.48 |
| $T_2$-$N_{15}P_{20}K_0$ | | | 6.44 | 4.52 |
| $T_3$-$N_{15}P_{40}K_0$ | | | 6.32 | 4.61 |
| $T_4$-$N_{15}P_{20}K_{20}$ | | | 6.47 | 4.57 |
| $T_5$-$N_{15}P_{40}K_{20}$ | | | 6.49 | 4.59 |
| $T_6$-$N_{15}P_{20}K_{40}$ | | | 6.50 | 4.62 |
| $T_7$-$N_{15}P_{40}K_{40}$ | | | 6.31 | 4.64 |
| $T_8$-$N_{15}P_{20}K_{60}$ | | | 6.30 | 4.54 |
| $T_9$-$N_{15}P_{40}K_{60}$ | | | 6.32 | 4.62 |
| $T_{10}$-$N_{15}P_{20}K_{20}$+*Rhizobium* | 6.32 | 4.45 | 9.11 | 7.91 |
| $T_{11}$-$N_{15}P_{20}K_{20}$+*Rhizobium*+PSB | | | 10.24 | 10.22 |
| $T_{12}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}$ | | | 6.23 | 4.60 |
| $T_{13}$-$N_{15}P_{40}K_0Zn_{21}S_{17}Mo_{2.0}$ | | | 6.52 | 4.58 |
| $T_{14}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{0.5}$ | | | 6.49 | 4.54 |
| $T_{15}$-$N_{15}P_{40}K_0Zn_{10.5}S_{8.5}Mo_{1.0}B_{1.0}$ | | | 6.52 | 4.53 |
| SEm(±) | | | 0.052 | 0.038 |
| CD(P=0.05) | | | 0.162 | 0.120 |
| CV% | | | 1.51 | 1.47 |
| RBD(0.05) | | | S | S |

**Table 5: Microbial population in soil after harvesting of lentil**

## CONCLUSION

Integrated Nutrient Management is one of the important issues for sustainable crop production. The result of the study revealed that integrated application of NPK with sulphur, boron, molybdenum, and zinc along with biofertilizers recorded higher grain yield, total biological yield, crude protein content as well as protein yield, nutrient accumulation as well as uptake and maintained soil fertility. Combined application of sulphur, boron, molybdenum, zinc increased the use efficiency of N, P and K. Integrated nutrient applications are more beneficial when the rate of the nutrient application is below the normal rate. It also improved the crop yields, quality of the produce as well as improves the soil fertility, thus the overall profit of the farmers. Thus, it may be recommended for the farmers of red and lateritic belt of West Bengal.

**REFERENCES**


1. Takkar P N , Chhibba I M, and Mehta S K (1989) Twenty years of coordinated research on Micronutrients in Soil and Plants, 1967-87, Bulletin 1, Indian Institute of Soil Science, Bhopal.
2. Swarup A and Ganeshamurthy A N (1998) Emerging nutrient deficiencies under intensive cropping systems and remedial measures for sustainable high productivity. *Fertilizer News*; 43(7), 37-40 and 43-50
3. Singh S P, Dhayani B P, Shahi U P, Kumar Ashok, Singh R R, Kumar Y, Kumar S and Baliyan Vikash (2009) Impact of Integrated Nutrient Management on yield and nutrient uptake in rice(*Oryza sativa*)-Wheat (*Triticum aestivum*) under rice-wheat cropping system In sandy loam soil. *Indian Journal of Agril. Sc.;* 79: 65-69
4. Pattanayak S K, Mohanty R K and Sethy A K(2001) Response of okra to *Azotobactor*, *Azospirillium* and FYM. Second North Eastern Regional Conference on Biofertilizers, Assam Agricultural University, Jorhat, Assam.
5. Jahiruddin M, M S Haque, Haque A K M M and Ray P K (1992) Influence of boron, copper and molybdenum on grain formation in wheat. *Crop Res*.; 5**:** 35-42
6. Mukherjee P K and Rai R K (2000) Effect of vesicular arbuscular mycorrihizae and phosphate solubilizing bacteria on growth, yield and phosphorus uptake by wheat (*Triticum aestivum*) and chickpea (*Cicer arietinum*). *Indian J. Agron.;* 45(3): 602-607.
7. Bera A K (2008) Effect of irrigation and nutrient management on growth and yield of lentil (*Lens culinaris* Medik). M.Sc.thesis. Palli Siksha Bhavana, Visva-Bharati.
8. Saha A R, Maitra D N, Majumdar B, Saha S and Mitra S (2008) Effect of Integrated nutrient Management of Roselle(*Hibiscus sabdariffa)* productivity, its mineral nutrition and soil properties. *Indian journal of Agricultural sciences*; 78: 418-421
9. Mohapatra, B K, Maiti S and Satapathy M R,(2008) Integrated nutrient management in Potato(*Solanum tuberosum*)- Jute (*Corchorus olitorius*) sequence. *Indian journal of Agronomy*; 53: 205-209.
10. Khan A H, Islam A, Islam R, Begum S and Huq S I (1988) Effect of indigenous VAmycorrhizal fungi on nodulation, growth and nutrition of lentil (*Lens culinaris*) and black gram (*Vigna mungo*). *Journal of Pl. Physiology*; 133(1): 84-88.
11. Thakur R, Swarkar S D, Vaishya U K, and Singh M (2009) Long term effect of organic fertilizers and organic manure on crop yields, nutrient uptake and soil health under soybean-wheat cropping system in a Typic Haplustert. *JNKVV Research Journal*; 43:181-184.
12. Deshmukh C and Jain A (2014) integrated nutrient management on protein content of lentil seeds under rainfed condition. *International Journal of Plant Sciences;* 9 (1) : 193-195
13. Brown M E (1975) Rhizosphere microorganisms-opportunities bandits or benefectors. In : *Soil Microbiology* (Ed.) N. Walker, Halsted Press, New York, pp.21-38.
14. Katznelso E (1962) Phosphate dissolving microorganisms on seed and in root zone of plants. *Canadian Journal of Botany*; 40: 1041-1180.
15. Kundu B S and Gaur A C(1980) Effect of phosphor-bacteria on the yield and phosphate uptake of potato crop. *Current Science*; 49: 159-228.


**CITATION OF THIS ARTICLE**

G Sahu, N Chatterjee and G K Ghosh. Integrated Nutrient Management In Lentil (*Lens culinaris* Medikus) In Red And Lateritic Soils Of West Bengal. Bull. Env. Pharmacol. Life Sci., Vol 6[4] March 2017: 55-62