International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(1): 1095-1097

Received: 19-11-2018
Accepted: 23-12-2018

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Response of lentil varieties to biofertilizers inoculation under different dates of sowing after rice

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Abstract
A field experiment was conducted during *rabi* season of 2013-14 and 2014-15 at Krishi Vigyan Kendra, Bahraich to assess the performance of three lentil (*Lens culinaris* M.) varieties (NDL-1, HUL-57 and L-4594) at four biofertilizer inoculants (no inoculation, *Rhizobium* alone, PSB alone, and *Rhizobium* + PSB) with two dates of sowing (15 November and 30 November). There was a significant reduction in seed yield with delay in sowing from 15 November to 30 November. Lentil sown on 15 November (17.7 qha^{-1}) out yielded to crop sown on 30 November with % increase in yield by 12.0 %. The crop sown on 15 November recorded higher net returns (Rs. 39,545 ha^{-1}) and benefit: cost ratio (2.35) than 30 November sown lentil crop which in turn recorded (Rs. 33,595 ha^{-1}) net returns, and benefit: cost ratio (2.0). Combined inoculation of *Rhizobium* + PSB was found effective for productivity and profitability point of view as compared to their alone inoculation. Combined inoculation recorded significant higher seed yield. (17.5 qha^{-1}), net returns (Rs. 38,815 ha^{-1}), B:C ratio (2.31). The variety L-4594 produced significantly higher yield of 17.5 q/ha as compare to NDL -1 (16.6 q/ha) and HUL-57 (16.1 q/ha).

Keywords: sowing dates, biofertilizers, varieties, yield, economics, lentil

Introduction
Lentil (*Lens culinaris* Medikus) is one of the important legumes growing in *rabi* season in India. It is mainly cultivated as sole crop after harvesting of paddy on residual soil moisture (Ali *et al.,* 2012) [12]. In India, lentil is grown on 1.34 million hectares during the 2013-14 and contributed 1.02 million tonnes grain to the national pulse baskets with an average productivity of 759 kg ha^{-1} (Anonymous, 2015) [1]. In Uttar Pradesh, lentil is grown on 6.08 lakh hectare with a production of 45.79 lakh tonnes. The average productivity of lentil is 715 kg ha^{-1}. Which is considerly low as compare to other states. Uttar Pradesh accounts 40 % of area and 46 % of the total production of the lentil. (Kokate *et al.,* 2013) [6].
Low productivity of lentil may be ascribed to many reasons but inadequate and imbalanced fertilization, and lack of suitable genotypes are the major factors responsible for low productivity. Identification of high- yielding adaptable variety is considered to the first and foremost step for increasing productivity. Keeping in view the. rest of inorganic fertilizer and its adverse effect on soil fertility, Judicious use of fertilizers with integration of biofertilizers is utmost important. Use of efficient strains of *Rhizobium* and phosphate solubilising bacteria may help, not only in increasing nutrient- use efficiency and yield but also reducing the cost of cultivation. The information on performance of lentil varieties and biofertilizer at different sowing dates are meagre. Therefore, the present investigation was carried out to study the performance of lentil varieties with bio fertilizer inoculants under different sowing dates.

Materials and Methods
A field experiment was conducted during the *rabi* season of 2013-14 and 2014-15 at Krishi Vigyan Kendra, Bahraich of N.D. University of Agriculture & Technology, Faizabad (Uttar Pradesh). The KVK farm is located at $27^0$34'N latitude and $81^0$35'E longitude with an elevation of 124 m above mean sea-level. The soil of the experimental field was sandy loam in texture, having pH 7.6, organic carbon 4.1 g kg^{-1}, available nitrogen 191.7 kg ha^{-1}, phosphorus 22.4 kg ha^{-1} and potassium 201.8 kg ha^{-1}. The treatment comprised of two sowing dates viz. 15 November, and 30 November, four levels of biofertilizers, with no inoculation,

Rhizobium, phosphate solubilizing bacteria (PSB) and *Rhizobium*+ PSB, and three varieties viz. NDL-1, HUL-57 and L-4594 were tested in split-split plot design, keeping sowing dates in main plot, biofertilizersin sub-plot, and varieties in ultimate plot with three replication. The recommended dose of fertilizers 20 N + 40 P_2O_5 kg/ha were applied through DAP @100 kg/ha. at the time of sowing uniformly in all the treatments. Seed of lentil varieties as per treatment was treated with *Rhizobium*@ 10 g kg^{-1}. PSB was applied in furrows @ 20 g kg^{-1} seed mixed with FYM. After seed inoculation with biofertilizers as per treatment. Lentil varieties were sown at dates on 15 November and 30 November in both the years. The seeds were sown in rows 25 cm apart using a seed rate of 35 kg ha^{-1} during both years. Other package of practices were followed as per the recommendations for the crop in the *terai* zone. The data on yield attributes viz. no. of pods/plant, grains/plant, branches/plant, weight of grain/plant were recorded on 5 plants, selected randomly from each plot at harvest of crop. To workout the economic viability of treatment, gross income, net income and BCR was calculated on the basis of grain and stover yield of each treatment on the basis of prevailing market prices. The net monetary returns were calculated by deducting the total cost of cultivation from the gross income for each treatment. The data so obtained on various characters were subjected to analysed statistically as per procedure described by Chandel-1978 [3].

Results and Discussion

Effect of sowing dates

Sowing dates a effected significantly the growth, yield attributes and yield of lentil (Table 1). There was significant reduction in seed yield with delay in sowing from 15 November to 30 November sowing. Lentil sown on 15 November(17.7 q ha^{-1}) out yielded to sowing date on 30 November and gave 12.0 % more grain yield over 30 November sowing. Roy *et al.* (2009) [8] and Singh *et al.* (2009) [10] reported similar results. The increasing seed yield in early sowing date may be ascribed to better growth and yield attributes due to its longer duration. More number of days taken for 50 % flowering and longer duration of crop in early sowing might have led to the development of better sink by better utilization of growth resources which were later on translocated to pods and seeds than its delayed sowing. The sowing of 15 November resulted in 5.4% more pods and 6.6% higher 1000- seed weight compared to 30 November sowing. The highest protein yield was recorded with 15 November sowing over 30 November sowing due to higher yield with 15th Nov sowing crop. Delay in sowing from 15 November to 30 November reduced the net returns as well as benefit: cost ratio (Table 1). The crop sown on 15 November provided the maximum net returns (Rs 30,545 ha^{-1}) and it was 17.7 % higher than from that sown on 30 November despite having similar cost of cultivation in both the sowings.

Effect of Biofertilizer

There was significant reduction in days to 50% flowering and days to maturity due to single inoculation of *Rhizobium* and PSB alone or dual inoculation over no inoculation. Dual inoculation of seed with *Rhizobium* + PSB recorded marked reduction in days taken to flowering and maturity by 6.2 and 5.9 days respectively over no inoculation. A progressive increase in plant height and number of branches/plant was over served with combined inoculation of *Rhizobium* + PSB, followed by inoculation of *Rhizobium* or PSB alone (Table 1). Biological N fixation by *Rhizobium*, greater release of P by phosphate-solubilizing bacteria and synthesis of growth-promoting hormones and vitamins by these microbes might have favoured the plant growth characters. At the same time plant height and branches/plant recorded under single inoculation with PSB or *Rhizobium* alone were almost equal, and proved significantly superior over no inoculation.

Biofertilizers inoculation significantly improved the pods/plant, and the magnitude of increase was more under combined inoculation by 20.4 % compared to no inoculation followed by *Rhizobium* or PSB alone. The benefits of biofertilizers might be ascribed to N addition through biological N fixation by *Rhizobium*, activation amino acids for synthesis of carbohydrates and P-solubilization by phosphate- solubilizing bacteria. Combination-inoculation of biofertilizers produced heavier seeds, which might be accorded to the better translocation of photosynthates to grain. Beneficial effect of biofertilizers in improving the seed and stover yield of lentil was noticed (Table 2) and the combined inoculation of *Rhizobium* + PSB showed more positive effects, indicating the synergistic association between them. The improvement in seed yield over no inoculation was 16.9% under combined inoculation, 10.4 and 8.4 % under individual inoculation of *Rhizobium* and phosphate solubilizing bacteria, respectively. At the same time single inoculation proved equally efficient and both proved significantly superior over no inoculation in seed and stover yield. Similar finding have been reported by Singh *et al.* (2010) [9] and Iqbal *et al.* (2012) [5]. Amongst the bioferttilizers treatments, *Rhizobium* + PSB recorded significantly higher grain protein (22.9%) as well as protein yield (412.20 kg ha^{-1}), followed by *Rhizobium* or PSB alone. The response of dual biofertlizers in improving seed quality may be attributed to their significant role in regulating the photosynthesis, root enlargement and better microbial activities. Combined inoculation of both the biofertilizers resulted in the highest net returns (Rs 40,500/ha) and benefit: cost ratio (2.40) validating the opinion that these two are complementary in improving the yield of legumes. At the same time *Rhizobium* or PSB alone proved equally efficient in terms of net returns and B:C ratio, and both of these proved significantly superior over no inoculation.

Effect of varieties

All the varieties recorded marked variation in days taken to 50 % flowering, maturity, number of branches/plant, pods/ plant, seeds/pod and 1000-seed weight (Table 1). Variety HUL-57 recorded significant reduction in days to 50% flowering and maturity days than L-4594 and NDL-1. Lentil variety L-4594 recorded significantly higher values of pods/plant and seeds/pod than NDL-1 and HUL-57, whereas L-4594 and HUL-57 being at par in terms of 1000 –seed weight. This could be attributed to genetical variation exist among lentil cultivars. L-4594 produced significantly highest seed yield (17.5 q ha^{-1}) which was higher over HUL-57 and NDL-1 by 8.7 and 5.4%, respectively (Table 2). Varietal differences including L-4594 and HUL-57 were also reported by Gautam *et al.* (2013) [4] and Reja *et al.* (2017) [7]. Increase in growth, yield attributes and yield depends in the genetic potential of cultivars and climatic condition during growing period of crop. Among the varieties, L-4594 brought about higher net returns (238.81 /ha) and benefit: cost ratio (2:31) than other varieties due to higher grain yield (Table 2). Amongst the varieties, the maximum protein yield was recorded in L-4594 and this was statistically superior to the cultivars NDL- 1 and

HUL-57. The higher protein yield from L-4594 was due to its higher yield.

Table 1: Effect of sowing dates, biofertlizers and varieties on growth and yield attributes of lentil (mean of two years)

Treatment	Days to 50 % flowering	Days to maturity	Plant height (cm)	Branches/ plant	Pods /plant	Seed /pod	1000-Seed weight (g)
Sowing date							
15 November	102.8	136.0	39.8	11.8	73.5	1.79	22.6
30 November	100.6	132.0	38.6	10.2	69.7	1.72	21.2
CD (P=0.05)	0.8	1.1	0.6	0.50	0.77	NS	0.20
Biofertilizer							
No inoculation	105.6	137.4	37.1	9.7	64.1	1.51	21.6
Rhizobium	100.4	134.2	39.9	11.2	73.0	1.82	22.0
PSB	101.5	133.0	39.8	11.2	72.4	1.82	21.9
Rhizobium + PSB	99.4	131.5	40.3	11.9	77.2	1.90	22.4
CD (P=0.05)	3.4	2.9	1.2	0.48	1.41	0.11	0.60
Variety							
NDL-1	104.7	138.1	39.4	10.5	71.3	1.75	22.3
HUL-1	98.5	130.4	38.1	10.1	69.1	1.62	21.7
L-4594	101.9	133.5	40.2	12.6	74.6	1.90	21.8
CD (P=0.05)	1.9	2.4	NS	0.39	0.91	0.08	0.09

Table 2: Effect of sowing dates, bio fertlizers and varieties on yield, quality and economics of lentil (mean of two years)

Treatment	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Grain Protein Content (%)	Protein yield (kg ha^{-1})	Net Returns ($x10^3$Rs ha^{-1})	B:C ratio
Sowing date						
15 November	17.7	32.2	22.6	400.02	39.54	2.35
30 November	15.8	29.7	22.8	360.24	33.59	2.00
CD (P=0.05)	0.80	1.3	NS	16.6	2.01	0.19
Biofertilizer						
No inoculation	15.4	28.0	22.4	344.96	32.28	1.93
Rhizobium	17.0	31.2	22.8	387.60	37.34	2.22
PSB	16.7	31.4	22.7	379.09	36.46	2.17
Rhizobium + PSB	18.0	33.3	22.9	412.20	40.50	2.40
CD (P=0.05)	0.87	2.3	0.11	11.4	2.35	0.19
Variety						
Nareula Masoor-1	16.6	31.4	22.7	376.82	36.16	2.15
HUL-1	16.1	30.6	22.9	368.70	34.58	2.06
L-4594	17.5	30.9	22.5	393.75	38.81	2.31
CD (P=0.05)	0.18	NS	NS	10.3	1.13	0.10

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