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Interactive effect of date of sowing and different source of nitrogen on growth and yield of lentil (*Lens culinaris* L)

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Abstract
A field experiment was carried out at the Agricultural Research farm, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur, India during the year 2019-2020 to study the performance of lentil under different dates of sowing and nutrient management. The result showed that the growth and yield and yield attributes of lentil were significantly influence by the different date of sowing and nutrient management. The highest growth and yield attributes were recorded from D_2 and N_2 whereas; the lowest were recorded from D_3 and N_1 respectively at different growth stages. The interaction effect between the date of sowing and nutrient management of lentil also exerted significant influence on growth and yield parameters and yield of lentil. The treatment D_2N_2 (Sowing on 4th November with 50% urea + 50% vermicompost + 100% SSP + 100% MOP) recorded the maximum grain yield (934.81 kg ha^{-1}) and stover yield (1478.06 kg ha^{-1}). Lentil sown on 4th November with a combined application of urea and vermicompost *i.e.* (D_2N_2) gave 22.49% higher grain yield from D_3N_1. From the result it can be concluded that the first week of November along with the combined application of urea and vermicompost as source of nitrogen is the optimum time of sowing and nutrient management of lentil as compared to other treatment combination.

Keywords: Lentil, date of sowing, vermicompost, nutrient management

1. Introduction
As pulses are an integral part of vegetarian diets of our country, it also occupy special place in diets of the Indian population. Pulses are the richest source of plant-based protein. They are known to increase productivity of soil through nitrogen fixation from the atmosphere, addition of biomass to soil and secretion of growth promoting substances. Lentil is an important pulse crop and nutritious food legume grown during the *rabi* season throughout India under varied agro-ecological conditions. This crop ranks second in acreage and production, third in protein content in pulses grown in South Asia (SAIC, 2010) [20]. In India, the annual lentil production ranges from 1.1 – 1.5 million tons, while the global production is 6.3 million tons a year. Nearly 3.7 million tons of total production is grown by Canada (FAO, 2019) [5]. While cultivated lentils covers roughly 1.5 million hectares of India's arable land, each hectare only produces 847-1000 kilograms of lentils, significantly below the global average of 1260 kg ha^{-1}. There are many factors for low productivity of lentil, including unsuitable time of sowing and improper nutrient management. In Manipur, HUL-57 is a popular variety of lentil which is hardy and can be grown successfully under rain fed conditions.
Time of sowing, a non-monetary input, has a considerable influence on growth and yield of this crop. Sowing time determines the time available for vegetative growth before flowering which is mainly influenced by photoperiod. Optimum sowing time provides more time for the growth and development of plant which is favorable for higher yield whereas both early and late sowing hinder the growth and development with.
Selecting the right nutrient management is important in order to obtain maximum grain yield and quality in agricultural production; otherwise grain yield decreases and chemical composition weaken. The indiscriminate use of chemical fertilizers without organic manures is known to degrade physico-chemical as well as biological properties of soil. On the other hand, the combined application of inorganic fertilizer and organic fertilizer results in improved moisture holding capacity, supply of micronutrients and availability of major nutrient due to favorable soil conditions. Since the information was scanty on these aspects; the present research work was undertaken.

2. Materials and methods

A field experiment was conducted at the experimental site of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur, India during the *rabi* season of the year 2019-2020 (Latitude: 24.72^0 N and Longitude: 93.83^0 E). The soil of the experimental site was clay having pH (5.2), EC (0.4 dS m^{-1}), OC (1.04%), available N (296.81 kg ha^{-1}), P (38.47 kg ha^{-1}) and K (254 kg ha^{-1}) respectively. The experiment was laid out in Split Plot Design with three levels of date of sowing (D_1 :15th October, D_2 : 4th November and D_3 : 19th November respectively) was allotted on the main plot and three level of nutrient management (N_1 : 100% urea + 100% SSP + 100% MOP, N_2 : 50% urea + 50% vermicompost + 100% SSP + 100% MOP and N_3 :100% vermicompost + 100% SSP + 100% MOP respectively) was allotted along the sub-plot. The lentil variety HUL-57 was sown in line with seed rate of 30 kg ha^{-1}. Biometric parameters namely plant height, number of branches, dry weight were recorded periodically at 25, 50, 75 DAS and at harvest. Yield attributing parameters like number of pods per plant, number of seeds per pod and test weight were recorded at harvest. Grain and stover yield were recorded plot wise and then expressed as kg ha^{-1}. The data collected from the experiment at different growth stages was subjected to statistical analysis as described by Gomez and Gomez (1984). The statistical differences of the data generated for each character were tested with least significant difference (LSD) at 5% probability level using analysis of variance technique (ANOVA). The standard error of means (SEm ±) and critical difference (CD) at 5% level of significance were calculated to compare the treatment means.

Results and discussion

Growth attributes

Plant height (cm)

Perusal of data revealed that the plant height of different date of sowing and nutrient management of lentil was significantly influenced for all the growth stage except for 25DAS (Table 1). This might be due to inefficacy of plant to absorb the applied nutrient properly at early growth stage. Among the different date of sowing, the highest plant height were recorded from D_2 (5.89, 13.06, 21.47 and 32.49 cm) respectively at 25, 50 and 75 DAS and at harvest which might be due to the favorable environmental condition for the growth as alteration in the date of sowing changes both the macro and micro environment in which a crop grows, as compared to other two date of sowing (20th October and 19th November). The finding was in accordance with Gill (2013) [6]; and Ouji and Mouelhi (2017) [16] who also reported that the plant height of early sown crops were significantly superior to late sown crop. Among the different nutrient management, the highest plant were recorded from N_2 (5.44, 12.14, 20.29 and 31.07 cm) respectively at 25, 50 and 75 DAS and at harvest which may be due to integrated application of chemical and organic fertilizer as combined application increase the available soil N and other plant nutrient. Similar findings were also corroborated by Das *et al.* (2002) [4] who revealed that that greater plant height were obtained with treatments containing vermicompost along with chemical fertilizer.

The interaction effect of date of sowing and plant nutrient management shows that the treatment D_2N_2 has the highest plant height (6.13, 13.33, 21.75, 33.89 cm) respectively at 25, 50 and 75 DAS and at harvest. This may be due to different time of sowing then the other two treatments which lead to proper uptake of plant nutrient by the crop which ultimately leads to proper plant growth. Similar findings were also corroborated by Sen *et al.* (2016) [21].

Number of branches per plant

Results showed that the number of branches of different date of sowing and nutrient management of lentil was significantly influenced for all the growth stage except for 25DAS (Table 1). This might be due to inefficacy of plant to absorb the applied nutrient properly at early growth stage. Among the different date of sowing, the highest number of branches were recorded from D_2 (1.55, 2.81, 5.59 and 7.20) respectively at 25, 50 and 75 DAS and at harvest. This might be due to more favorable environmental condition prevalent during the crop period. The results were similar with findings of Yadav *et al.* (2018) [22] and Gill (2013) [6]. Among the different nutrient management, the highest number of branches of lentil was recorded from N_2 (1.53, 2.73, 4.84 and 6.47). This might be attributed to the enrichment of soil fertility as influence by the application of organic fertilizer *i.e.* vermicompost as compared to the treatment which have only inorganic fertilizer. Similar, result was also reported by Sahu *et al.* (2017) [19].

The interaction effect of date of sowing and plant nutrient management shows that treatment D_1N_2 have the highest number of branches (1.63) at 25 DAS and the treatment D_2N_2 (2.92, 5.56 and 7.53) respectively at 50 and 75 DAS and at harvest. This might be attributed to the fact that the combine application of chemical fertilizer and organic fertilizer gave more synergetic effect in enhancing the growth attributes of the plant. Similar, findings were also reported by Chouhan (2011) [3].

Dry weight (g)

The analyzed data showed that the dry weight of different date of sowing and nutrient management of lentil was significantly influenced for all the growth stage except for 25 DAS (Table 1). Among the different date of sowing, the highest amount of dry weight per plant was recorded from D_2 (0.21, 0.69, 3.10 and 5.16 g) respectively at 25, 50 and 75 DAS and at harvest followed by D_1. This might be to variation in overall growth and development of individual plant as it is also evident from various growth observations like plant height and branches per plant. An increase of dry matter accumulation in the early sowing date was also reported by Kazemekas (2001) [12]. Among the different nutrient management, the highest dry weight of lentil was recorded from N_1 (0.19 g) at 25 DAS and N_2 (0.58, 2.81 and 4.88 g) respectively at 50 and 75 DAS and at harvest. As in N_2 there was combine application of chemical and organic fertilizer which may lead to better growth of the plant as we can observe from the data of plant height and number of branches. This result was supported by the finding of Das *et al.* (2002) [4], who revealed that application of recommended fertilizer dose along with vermicompost give better dry matter accumulation.

The interaction effect of date of sowing and plant nutrient management shows that treatment D_2N_1 have the highest dry matter accumulation (0.22 g) at 25 DAS and the treatment D_2N_2 (0.70, 3.19 and 7.53 g) respectively at 50 and 75 DAS and at harvest. This might be attributed to the fact that the combine application of chemical fertilizer and organic

fertilizer gave more synergetic effect in enhancing the growth attributes of the plant. Similar, findings were also reported by Chouhan (2011) [3]. The results were supported by the finding of Rao *et.al.* (2000) [18] and Gulmezoglu *et al.* (2011) [8].

Table 1: Effect of date of sowing and nutrient management on plant height (cm), number of branches and dry weight (g) per plant of lentil

Treatment	Plant height (cm)				No. of branches/plant				Dry weight/plant (g)			
	25 DAS	50 DAS	75 DAS	Harvest	25 DAS	50 DAS	75 DAS	Harvest	25 DAS	50 DAS	75 DAS	Harvest
Date of sowing												
D_1	5.28	11.52	19.64	30.34	1.43	2.58	4.41	6.04	0.18	0.54	2.67	4.71
D_2	5.89	13.06	21.47	32.49	1.55	2.81	5.59	7.20	0.21	0.69	3.10	5.16
D_3	5.06	11.24	19.21	27.82	1.30	2.43	4.23	5.62	0.16	0.44	2.34	4.41
SEm (±)	0.03	0.10	0.08	0.21	0.08	0.03	0.05	0.07	0.01	0.00	0.01	0.02
CD (5%)	NS	0.28	0.22	0.58	NS	0.07	0.13	0.20	NS	0.01	0.02	0.05
Nutrient management												
N_1	5.27	11.72	19.85	29.51	1.32	2.53	4.60	6.08	0.19	0.56	2.58	4.67
N_2	5.44	12.14	20.29	31.07	1.53	2.73	4.84	6.47	0.18	0.58	2.81	4.88
N_3	5.03	11.96	20.11	30.07	1.43	2.56	4.64	6.31	0.18	0.53	2.69	4.72
SEm (±)	0.08	0.09	0.08	0.14	0.11	0.02	0.03	0.05	0.01	0.01	0.00	0.01
CD (5%)	NS	0.20	0.18	0.30	NS	0.05	0.07	0.12	NS	0.01	0.01	0.02
Date of sowing × Nutrient management												
D_1N_1	5.22	11.44	19.59	30.02	1.27	2.59	4.27	5.9	0.17	0.57	2.46	4.55
D_1N_2	5.13	11.61	19.61	30.69	1.63	2.65	4.60	6.20	0.18	0.58	2.88	4.89
D_1N_3	5.48	11.53	19.64	30.31	1.41	2.52	4.36	6.01	0.18	0.47	2.67	4.68
D_2N_1	5.50	12.61	20.85	31.35	1.51	2.74	5.26	6.87	0.22	0.67	3.05	5.11
D_2N_2	6.13	13.33	21.75	33.89	1.53	2.92	5.56	7.53	0.20	0.70	3.19	5.20
D_2N_3	6.03	13.25	21.47	32.23	1.60	2.77	5.35	7.19	0.20	0.69	3.06	5.15
D_3N_1	5.10	11.12	19.11	27.15	1.19	2.27	4.26	5.47	0.18	0.44	2.23	4.35
D_3N_2	5.06	11.49	20.29	28.65	1.43	2.63	4.35	5.67	0.16	0.46	2.35	4.54
D_3N_3	5.03	11.10	20.11	27.67	1.27	2.38	4.10	5.72	0.14	0.42	2.34	4.34
SEm (±)	0.13	0.16	0.14	0.24	0.19	0.04	0.06	0.10	0.02	0.01	0.01	0.02
CD (5%)	NS	0.34	0.31	0.51	NS	0.09	0.13	0.21	NS	0.02	0.02	0.03

Yield attributes

Number of pods per plant

The analyzed data regarding the no. of pods per plant was significantly influenced by different date of sowing and nutrient management of lentil (Table 2). Among the different date of sowing, the highest no. of pods per plant was recorded from D_2 (81.35) followed by D_1. The overall growth and development of individual plant as like branches per plant helps in increasing the no. of pods per plant. Among the different nutrient management, the highest no. of pods per plant was recorded from N_2 (78.53) followed by N_3.

The interaction effect of date of sowing and plant nutrient management shows that treatment D_2N_1 have the highest no. of pods per plant (82.58) followed by D_2N_3. This might be due to having more number of branches in this treatment. Ceritoglu and Erman (2020) [2] reported by that pods per plant varies from 20.8-54.5 pods per plant, the highest being at the crops sown on 1st Dec. and the lowest at 15th Oct along with vermicompost. Similar findings were also reported by Kasuhik and Singh (2022) [11].

Number of seeds per pod

The no. of seeds per pod was significantly influenced by different date of sowing and nutrient management of lentil (Table 2). Among the different date of sowing, the highest no. of seeds per pod was recorded from D_2 (1.70) followed by D_1 and D_3 which are statistically at par with each other. Among the different nutrient management, the highest no. of seeds per pod was recorded from N_2 (1.69) followed by N_3.

The interaction effect of date of sowing and plant nutrient management shows that treatment D_2N_2 have the highest no. of seeds per pod (1.72) followed by D_2N_3. This might be due to the application of vermicompost + N in the form of urea at the early growth stage. Humic and fulvic acids and other organic acids found in vermicompost, as well as frequency of nutrient specially nitrogen can stimulate plant growth as reported by Hosseinzadeh and Ahmadpour (2016) [10]. The finding were corroborated with the findings of Moosavi *et al.* (2014) [15]

Test weight (g)

Test weight is an important index of grain health. Though this is basically a genotypic character, the treatments where there was application of vermicompost were found to produce healthy seed. The test weight was significantly influenced by different date of sowing and nutrient management of lentil (Table 2). Among the different date of sowing, the highest test weight was recorded from D_2 (19.95 g) followed by D_3. Among the different nutrient management, the highest test weight was recorded from N_2 (19.70 g) followed by N_3.

The interaction effect of date of sowing and plant nutrient management shows that treatment D_2N_2 have the highest test weight (19.98) followed by D_2N_3. This might be due to the better microbial activity which helps the crop to attain good vigour and to produce healthy seed. The results were in conformity with those of Kasuhik and Singh (2022) [11].

Table 2: Effect of date of sowing and nutrient management on pods per plant, seeds per pod and test weight (g) of lentil

Treatment	Number of pods/plant	Number of seeds/pod	Test weight (g)
Date of sowing			
D_1	76.82	1.65	19.74
D_2	81.35	1.70	19.95
D_3	74.86	1.65	18.98
SEm (±)	0.05	0.00	0.02
CD (5%)	0.15	0.01	0.06
Nutrient management			
N_1	76.95	1.65	19.43
N_2	78.53	1.69	19.70
N_3	77.54	1.67	19.53
SEm (±)	0.06	0.00	0.02
CD (5%)	0.13	0.01	0.05
Date of sowing × nutrient management			
D_1N_1	76.30	1.63	19.63
D_1N_2	77.66	1.68	19.82
D_1N_3	76.50	1.65	19.77
D_2N_1	80.11	1.69	19.92
D_2N_2	82.58	1.72	19.98
D_2N_3	81.36	1.70	19.95
D_3N_1	74.45	1.63	18.75
D_3N_2	75.37	1.66	19.30
D_3N_3	74.75	1.66	18.88
SEm (±)	0.10	0.01	0.04
CD (5%)	0.22	0.01	0.09

Grain yield (kg ha^{-1})

The crop yield potential of crop is decided by the growth and yield components. This was reflected in the present investigation as the highest and the lowest grain yield was obtained from those treatments which were found to have better growth and yield component. The grain yield was significantly influenced by different date of sowing and nutrient management of lentil (Table 3). Among the different date of sowing, the highest grain yield was recorded from D_2 (912.24 kg ha^{-1}) followed by D_1. This might be due to early sowing which helped to absorb nutrients and translocate the photosynthates from source to sink efficiently. Among the different nutrient management, the highest grain yield was recorded from N_2 (864.77 kg ha^{-1}) followed by N_3. This might be due to the cumulative effect of different nutrient management which increases the number of branches, number of pods per plant, number of seeds per pods and test weight altogether influenced higher production of grains.

The interaction effect of date of sowing and plant nutrient management shows that treatment D_2N_2 have the highest grain yield (934.81 kg ha^{-1}) followed by D_2N_3. Vermicompost which is rich in micro and macro plant nutrients that are in plant available form like nitrate (NO_3^-), phosphate (PO_4^{3-}), sulphate (SO_4^{2-}), potassium (K^+) *etc*. aids in plant growth promotion that increases crop productivity. The findings are in agreement with the findings of Mandi *et al.* (2015) [13] and Math *et al.* (2018) [14].

Stover yield (kg ha^{-1})

Higher grain yield released from the treatments seem to be associated with higher stover yield. The higher growth attributes like plant height and dry matter accumulation also reflected on the stover yield. The analyzed data showed that the stover yield was significantly influenced by different date of sowing and nutrient management of lentil (Table 3). Among the different date of sowing, the highest stover yield was recorded from D_2 (1451.85 kg ha^{-1}) followed by D_1. Among the different nutrient management, the highest stover yield was recorded from N_2 (1407.65 kg ha^{-1}) followed by N_3. Increased in stover yield might be due to the growth promoting effect of vermicompost which increased the level of cell division within the apical meristem of seedling root and caused higher plant growth and increased the dry matter production.

The interaction effect of date of sowing and plant nutrient management shows that treatment D_2N_2 have the highest stover yield (1478.06 kg ha^{-1}) followed by D_2N_3. The accumulation of carbohydrates in plants ultimately increased the yield attributes and increased the stover yield which might be due to active biochemical functions in plants, enzyme activation, photosynthesis and cell division. Similar findings were also reported by Sen *et al.* (2016) [21] and Gurung *et al.* (1996) [9] who reported the highest values for seed and stover yield by vermicompost application.

Harvest index (%)

The harvest index which is a measure of reproductive efficiency was significantly influenced by both date of sowing, nutrient management and also by their interaction (Table 3). Among the different date of sowing, the harvest index was highest for D_2 (38.51%) followed by D_1. Among the different nutrient management, the harvest index was highest for N_2 (38.03%) followed by N_3.

The interaction effect of date of sowing and plant nutrient management shows that treatment D_2N_2 have the highest harvest index (38.74%) followed by D_2N_3. This might be due the physiological index reflecting the percentage of assimilates mobilization from vegetative organs of plant into grains. The result was similar to the findings of Allam (2002) [1], who reported that the harvest index was higher when sowing was conducted on 1st and 15th November and Moosavi *et al.* (2014) [15] who concluded that delay in sowing significantly decreased harvest index. The variation in harvest index due to different date of sowing and different nutrient management could be explained with the variation in their grain and stover yield.

Based on the results from the experiment it can be concluded that sowing of lentil on 4th November with the combined application of urea and vermicompost is best for growth and yield attributes of lentil in comparison to other treatment combinations.

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Table 3: Effect of date of sowing and nutrient management on grain yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) of lentil

Treatment	Grain Yield (Kg ha^{-1})	Stover Yield (kg ha^{-1})	Harvest Index (%)
Date of sowing			
D_1	826.53	1362.30	37.76
D_2	912.24	1451.85	38.51
D_3	785.88	1331.91	37.12
SEm (±)	1.35	3.15	0.07
CD (5%)	3.76	8.74	0.16
Nutrient management			
N_1	816.82	1354.81	37.59
N_2	864.77	1407.65	38.03
N_3	840.25	1383.10	37.76
SEm (±)	1.84	2.71	0.07
CD (5%)	4.01	5.90	0.16
Date of sowing × nutrient management			
D_1N_1	806.09	1342.07	37.52
D_1N_2	853.44	1385.63	38.12
D_1N_3	820.04	1359.21	37.63
D_2N_1	886.90	1427.15	38.18
D_2N_2	934.81	1478.06	38.74
D_2N_3	912.24	1450.35	38.61
D_3N_1	763.12	1295.21	37.07
D_3N_2	806.05	1359.27	37.23
D_3N_3	788.47	1339.74	37.05
SEm (±)	3.19	4.69	0.12
CD (5%)	6.95	10.22	0.27

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