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Influence of seed rate and fertilizer levels on growth and yield of lentil (*Lens culinaris* Medik.) genotypes under dry land situation

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Abstract
The Field experiment was conducted at Regional Agricultural Research Station, Vijayapura in Northern dry zone of Karnataka on medium black soil to study the influence of seed rate and fertilizer levels on growth and yield of lentil *(Lens culinaris* Medik.) genotypes under dry land situation during *rabi* 2015-16. The experiment was laid out in Split split plot design with three genotypes as main plot (JL 3, IPL 316 and RVL 31), three seed rates as sub plot (30, 35 and 40 kg ha^{-1}) and two fertilizer levels as sub sub plot (25:50:25 kg and 10:30:00 kg N, P_2O_5 and K_2O ha^{-1}) treatments. The lentil genotype RVL-31 recorded significantly higher grain yield (130.7 kg ha^{-1}) and was on par with genotype JL-3 (121.0 kg ha^{-1}). Significantly higher yield was attributed to significantly higher growth and yield parameters *viz*., plant height at 60 DAS (20.7 and 19.7 cm, respectively), 100 seed weight (2.92 and 3.00 g, respectively) and harvest index (19.25 % and 16.39 %, respectively). The seed rate of 40 kg ha^{-1} recorded significantly higher grain yield (135.2 kg ha^{-1}), benefit cost ratio (1.09), straw yield (817.9 kg ha^{-1}), harvest index (17.3 %) and higher number of plants per m row length at 60 and at harvest (39.1 and 29.2, respectively). The fertilizer level of 25:50:25 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher grain yield (123.2 kg ha^{-1}), straw yield (801.2 kg ha^{-1}) and harvest index (15.95 %) compared to 10:30:00 kg N, P_2O_5 and K_2O ha^{-1}. The interaction of lentil genotype, RVL 31 with 40 kg ha^{-1} seed rate and fertilizer level of 25:50:25 kg N:P_2O_5:K_2O ha^{-1} recorded significantly higher grain yield (243.4 kg ha^{-1}) and benefit cost ratio (1.70) with better performance of growth and yield parameters.

Keywords: Lentil, Fertilizer, Genotype, Seed rate

Introduction
Lentil is the second most important winter season pulse crop after chickpea in India. The crop is commonly grown under rainfed condition during winter on soils that conserve moisture from the preceding monsoon**.** It requires cold temperature during vegetative growth and comparatively warm temperature during maturity, with the optimum temperature range of 18-26 ^{0}C. India ranks first in the area and second in the production with 43% and 37% of world area and production, respectively. The highest productivity was recorded in New Zealand (2667 kg ha^{-1}) followed by China (2239 kg ha^{-1}) as compared to India (600 kg ha^{-1}). In India, Madhya Pradesh is having highest area (39.59%, 5.50 lakh ha) followed by UP (33.95 %) and Bihar (11.29 %), respectively. While in terms of production UP is first ranked (34.36 %, 3.76 lakh tonnes) followed by Madhya Pradesh (30.73%) and Bihar (17.35%). The highest yield was recorded in Bihar (1209 kg ha^{-1}), while, the lowest yield was observed (Anonymous 2016) [1] in Chhattisgarh (327 kg ha^{-1}).

The lentil genotypes have inbuilt potential to provide relatively good production even in stress conditions *i.e.*, drought, frost and water logging. However, it is observed that extreme abnormal temperature at the time of fruit setting to pod development stages may reduce the productivity due to less fruit setting, non-healthy development of grain and forced maturity of grain. Some other causes responsible for low yield of lentil are use of traditional local cultivars, low plant density per unit area and poor crop management practices constituting the major ones. Use of the modern lentil cultivars and maintenance of proper plant density per unit area would thus help in increasing the yield from unit per area (Bhuiyan, 1976) [3].

Material and methods
The field experiment was conducted in medium black soils at Regional Agricultural Research Station, Vijayapura in Northern dry zone (Zone 3) of Karnataka to study the influence of seed rate and fertilizer levels on growth, yield and quality of lentil *(Lens culinaris* Medik.) genotypes under dry land situation. The experimental location is situated at 16^0 49' North latitude, 75^0 43' and East longitude and at an altitude of 593.8 m above the mean sea level.

The experiment was laid out in Split split plot design with three genotypes as main plot (JL 3, IPL 316 and RVL 31), three seed rates as sub plot (30, 35 and 40 kg ha^{-1}) and two fertilizer levels as sub sub plot (25:50:25 kg and 10:30:00 kg N, P_2O_5 and K_2O ha^{-1}) treatments. The soil was medium deep black with pH 7.4. The available N, P_2O_5 and K_2O contents were 192.5, 30.2 and 378.5 kg ha^{-1}, respectively. The row spacing followed was 30 cm. The rainfall during the crop growth period was only 27.1 mm. and there was a long dry spell of thirty seven days after sowing, during October and November during the crop growth period necessitating lifesaving light irrigation. The crop was harvested at physiological maturity. The experimental data were statistically analyzed using MSTAT-C programme. The level of significance used in F test was P=0.05. The mean values of interaction treatment were subjected to Duncan's Multiple Range Test (DMRT) using the corresponding error mean sum of squares and degrees of freedom values.

Results and Discussion

Effect of genotypes

Significantly higher seed yield (130.7 kg ha^{-1}) was recorded with the lentil genotype RVL 31 and it was on par with genotype JL 3 (121.0 kg ha^{-1}). The benefit cost ratio (1.04) was also significantly higher. The yield increase was 261.4 per cent and 242 per cent compared to genotype IPL 316 (50.0 kg ha^{-1}). Significantly higher seed yield with genotype RVL 31 and JL 3 was attributed to significantly higher growth and yield parameters *viz*., plant height at 60 DAS (20.7 and 19.7 cm, respectively), 100 seed weight (2.56 and 3.00 g, respectively), harvest index (19.25 and 16.39%, respectively). Similar findings of higher seed yield in lentil genotypes were reported by Mohammadjanloo *et al*. (2009) [8], Singh *et al*. (2011) [12] and Rahman *et al*. (2013) [10] due to higher growth and yield parameters.

Lentil crop essentially requires cooler temperature for its growth and development especially during reproductive phase. The significantly least seed yield with genotype IPL 316 (50.0 kg ha^{-1}) was due to significantly longer crop duration, lower growth and yield parameters. This indicates that due to longer crop duration it suffered from moisture stress at reproductive phase compared to other two genotypes. The higher temperature and moisture stress at reproductive phase results in less remobilization. Due to change in weather parameters *i.e*., shorter winter period resulted in reduced productivity. However, the genotypes RVL 31 and JL 3 performed comparatively better with respect to moisture stress and higher temperature though the yield levels were lower.

Effect of seed rate on growth and yield of lentil

The lentil crop sown with the seed rate of 40 kg ha^{-1} recorded significantly higher seed yield (135.2 kg ha^{-1}) and benefit cost ratio (1.09) compared to other seed rates. The yield increase was 54.86 per cent over 35 kg ha^{-1} seed rate and 70.70 per cent over 30 kg ha^{-1}. This was due to significantly higher number of plants per m row length at 60 and at harvest (39.1 and 29.2, respectively) and harvest index (16.63 %). The results are in conformity with the findings of Benati *et al.* (1988) [2], Saleem *et al*. (2012) [11], Eriksmoen *et al*. (2013) [5] who reported positive correlation of seed yield with seed rate.

The significantly least seed yield recorded with the seed rate of 30 kg ha^{-1} (79.2 kg ha^{-1}) was due to significantly lower number of plants per m row length at 60 and harvest (28.2 and 20.9, respectively). However, it recorded significantly higher growth and yield parameters. The better performance per plant was due to better utilization of resources. Despite significantly higher growth and yield parameters per plant, the reduction in seed yield compared to higher seed rate of 35 and 40 kg ha^{-1} was mainly due to lower plant population per unit area. The results are in conformity with the findings of Singh *et al*. (2005) [13] and Parveen and Bhuiya (2010) [9].

Effect of fertilizer levels on growth and yield of lentil

The higher fertilizer level of 25:50:25 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher seed yield (123.2 kg ha^{-1}) compared to the lower fertilizer level of 10:30:00 kg N, P_2O_5 and K_2O ha^{-1} (78.0 kg ha^{-1}). The yield increase was 57.94 per cent over 10:30:00 kg N, P_2O_5 and K_2O ha^{-1}. This was due to significantly higher growth and yield parameters *viz*., plant height at 60 DAS and at harvest (19.4 and 27.2 cm, respectively), plants per m row length at 60 and at harvest (36.1 and 26.8, respectively), seed yield per plant (0.45 g $plant^{-1}$), 100 seed weight (3.01 g), straw yield (801.2 kg ha^{-1}), harvest index (15.95 %). Singh *et al.* (2011) [12] also recorded increased shoot dry weight, plant height, branches per plant, pods per plant, biological and grain yields with increasing fertilizer levels. Similar findings were also reported by Kumar *et al*. (2010) [7], Choubey *et al.* (2013) [4] and Rahman, *et al.* (2013) [10].

Interaction effect of genotype, seed rate and fertilizer level

The interaction $G_3S_3F_1$ *i.e.*, genotype RVL 31 with seed rate of 40 kg ha^{-1} and fertilizer level of 25:50:25 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher seed yield (243.4 kg ha^{-1}) and benefit cost ratio (1.70) over rest of the interactions. This might be due to optimum combination of genotype, higher seed rate (plant population) and higher fertilizer level. Though per plant performance was lower, the significantly higher number of plants per m row length at 60 and at harvest (43.3 and 31.3, respectively) resulted in significantly higher yield. The significantly higher performance of individual effect of genotypes (G_3), seed rate (S_3) and fertilizer level (F_1) also contributed significantly to the higher yield with interaction $G_3S_3F_1$. These findings are in agreement with the results of Kumar *et al*. (2010) [7], Saleem *et al*. (2012) [11], Choubey *et al*. (2013) [4], Rahman *et al.* (2013) [10] and Eriksmoen *et al*. (2013) [5].

Conclusion

The lentil genotype, RVL 31 sown with seed rate of 40 kg ha^{-1} and fertilizer level of 25:50:25 kg N:P_2O_5:K_2O ha^{-1} recorded significantly higher seed yield (243.4 kg ha^{-1} and benefit cost ratio (1.70) with better performance of growth and yield parameters in dryland situation in Northern Karnataka.

Table 1: Growth, Yield parameters, yield and harvest index of lentil genotypes as influenced by seed rate and fertilizer levels under dryland situation

Treatment	Plant height (cm)		Plants per m row length		100 seed weight (g)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	Benefit cost ratio
	60 DAS	At harvest	60 DAS	At harvest						
Genotypes (G)										
G_1	19.7^{a}	26.5^{a}	34.6^{a}	25.0^{a}	3.00^{a}	0.48^{a}	121.0^{a}	655.3^{b}	16.39^{a}	1.00^{b}
G_2	16.6^{b}	26.6^{a}	33.3^{a}	24.4^{a}	2.56^{b}	0.33^{a}	50.0^{b}	817.2^{a}	6.11^{b}	0.55^{c}
G_3	20.7^{a}	26.2^{a}	35.8^{a}	26.0^{a}	2.92^{a}	0.34^{a}	130.7^{a}	653.5^{b}	19.25^{a}	1.04^{a}
S. Em±	0.38	0.70	1.00	0.76	0.058	0.048	3.26	1.26	0.829	0.005
Seed rate (S)										
S_1	19.6^{a}	27.9^{a}	28.8^{b}	20.9^{c}	3.01^{a}	0.44^{a}	79.2^{b}	599.1^{c}	11.09^{b}	0.72^{c}
S_2	19.4^{a}	25.9^{b}	35.8^{a}	25.2^{b}	2.83^{ab}	0.38^{b}	87.3^{b}	709.0^{b}	13.37^{ab}	0.78^{b}
S_3	18.0^{b}	25.6^{b}	39.1^{a}	29.2^{a}	2.65^{b}	0.32^{c}	135.2^{a}	817.9^{a}	17.30^{a}	1.09^{a}
S. Em±	0.18	0.52	1.18	1.06	0.061	0.016	5.65	0.99	1.219	0.002
Fertilizer levels (F)										
F_1	19.4^{a}	27.2^{a}	36.1^{a}	26.3^{a}	3.00^{a}	0.45^{a}	123.2^{a}	801.3^{a}	15.95^{a}	0.99^{a}
F_2	18.6^{b}	25.7^{b}	33.0^{b}	24.0^{b}	2.66^{b}	0.32^{b}	78.0^{b}	616.0^{b}	11.88^{b}	0.74^{b}
S. Em±	0.21	0.18	0.55	0.52	0.061	0.027	3.68	0.80	1.032	0.001
Interaction (G×S)										
$G_1S_1F_1$	20.6^{a-e}	28.5 $^{a-c}$	31.5^{d-g}	21.7^{d-g}	3.25^{a}	0.63^{a}	112.7^{cd}	711.4^{i}	14.14^{b-g}	0.93^{g}
$G_1S_1F_2$	19.2^{d-h}	28.2 $^{a-d}$	26.8^{gh}	20.2^{fg}	3.03^{a-c}	0.48^{a-c}	83.5^{de}	425.9^{n}	13.44^{b-g}	0.76^{h}
$G_1S_2F_1$	20.1^{a-f}	27.3 $^{a-f}$	37.3^{bc}	26.8^{a-d}	3.11^{ab}	0.59^{ab}	138.3^{c}	761.2^{f}	16.89^{b-f}	1.09^{d}
$G_1S_2F_2$	19.6^{c-g}	24.3^{ij}	34.3^{b-e}	23.3^{c-g}	2.96^{a-c}	0.36^{a-c}	74.9^{ef}	519.1^{l}	12.69^{c-g}	0.69^{i}
$G_1S_3F_1$	19.9^{b-g}	26.3^{e-h}	39.8^{ab}	30.8^{a}	3.07^{ab}	0.49^{a-c}	191.0^{b}	801.1^{d}	23.14^{a-c}	1.42^{b}
$G_1S_3F_2$	19.0^{e-h}	24.5^{h-j}	37.8^{b-e}	27.3^{a-c}	2.60^{b-e}	0.32^{bc}	125.7^{c}	713.3^{i}	18.02^{b-e}	1.08^{e}
$G_2S_1F_1$	17.8^{g-i}	27.7^{a-e}	29.2^{e-h}	21.5^{e-g}	2.79^{a-d}	0.47^{a-c}	48.1^{ef}	714.7^{i}	4.92^{g}	0.50^{q}
$G_2S_1F_2$	16.8^{ij}	27.4^{a-f}	25.0^{h}	19.3^{g}	2.86^{a-c}	0.34^{bc}	42.2^{f}	672.1^{j}	4.47^{g}	0.51^{p}
$G_2S_2F_1$	17.2^{h-j}	26.9^{b-g}	36.8^{b-e}	26.2^{a-e}	2.76^{a-d}	0.40^{a-c}	51.5^{ef}	944.8^{a}	7.00^{fg}	0.56^{m}
$G_2S_2F_2$	16.7^{ij}	26.6^{d-g}	32.8^{c-f}	22.8^{e-g}	2.22^{de}	0.25^{c}	44.0^{f}	836.0^{c}	6.33^{g}	0.55^{n}
$G_2S_3F_1$	15.7^{j}	25.3^{g-i}	38.2^{a-c}	29.3^{ab}	2.68^{a-d}	0.29^{c}	67.1^{ef}	951.9^{a}	8.08^{e-g}	0.64^{l}
$G_2S_3F_2$	15.6^{j}	25.8^{f-i}	37.5^{bc}	27.2^{a-c}	2.07^{e}	0.25^{c}	47.3^{ef}	783.9^{e}	5.87^{g}	0.54^{o}
$G_3S_1F_1$	22.1^{a}	28.8^{a}	31.7^{d-g}	21.8^{d-g}	3.19^{ab}	0.45^{a-c}	116.0^{cd}	642.8^{k}	17.45^{b-f}	0.94^{f}
$G_3S_1F_2$	21.2^{a-d}	26.7^{c-g}	28.5^{f-h}	21.2^{e-f}	2.93^{a-c}	0.30^{c}	72.6^{ef}	427.5^{n}	12.12^{d-g}	0.68^{j}
$G_3S_2F_1$	21.8^{ab}	25.2^{g-i}	37.5^{bc}	27.2^{a-c}	3.07^{ab}	0.41^{a-c}	140.4^{c}	751.1^{g}	23.77^{ab}	1.09^{d}
$G_3S_2F_2$	21.4^{a-c}	25.1^{ghi}	35.7^{b-d}	25.2^{b-f}	2.86^{a-c}	0.30^{c}	74.9^{ef}	442.0^{m}	13.52^{b-g}	0.67^{k}
$G_3S_3F_1$	19.3^{c-h}	28.7^{ab}	43.3^{a}	31.3^{a}	3.06^{ab}	0.33^{bc}	243.4^{a}	933.0^{b}	28.20^{a}	1.70^{a}
$G_3S_3F_2$	18.4^{f-i}	22.9^{j}	38.2^{a-c}	29.2^{ab}	2.42^{c-e}	0.27^{c}	136.6^{c}	724.4^{h}	20.47^{a-d}	1.16^{c}
S. Em±	0.63	0.55	1.66	1.56	0.182	0.082	11.05	2.42	3.097	0.003

DAS: Days after sowing

Means followed by the same lower case letter(s) in a column do not differ significantly by DMRT (P = 0.05).

G_1: JL-3 S_1: 30 kg ha^{-1} F_1 : 25:50:25 kg N:P_2O_5:K_2O ha^{-1}

G_2: IPL-316 S_2: 35 kg ha^{-1} F_2 : 10:30:00 kg N:P_2O_5:K_2O ha^{-1}

G_3: RVL-31 S_3: 40 kg ha^{-1}

Fig 1: General view of the experiment at 60 days after sowing

Fig 2: General view of the experiment at harvest

Fig 3: Plants of lentil genotypes at 90 days after sowing

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