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Response of lentil (*Lens culinaris* Medik.) genotypes to seed rate and fertilizer levels under protective irrigation

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Abstract: Field experiment was conducted at Regional Agricultural Research Station, Vijayapura in Northern dry zone of Karnataka on medium black soil to study the response of lentil (Lens culinaris Medik.) genotypes to seed rate and fertilizer levels under protective irrigation 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.*, pods per plant (13.65 and 17.20, respectively), seeds per pod (1.06 and 1.07, respectively), and harvest index (19.25 % and 16.39 %, respectively). The seed rate of 40 kg ha^{-1} recorded significantly higher grain yield (243.4 kg ha^{-1}), haulm yield (811.3 kg ha^{-1}), harvest index (16.63%) and higher number of plants per m row length at harvest (29.2).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}), haulm yield (801.2 kg ha^{-1}) and harvest index (15.95%), dry matter accumulation per plant at 60 DAS and harvest (0.37 and 1.51 g plant^{-1}, respectively) 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}) with better performance of growth and yield parameters.

Key words: Fertilizer, Genotype, Lentil, Seed rate

Introduction

Lentil (*Lens culinaris* Medik., 2n=14) is one of the oldest annual grain legumes consumed and cultivated in the world. It is an essential source of protein in many parts of the world. It is also an excellent source of vitamin A, vitamin B and provides fibre, potassium, and iron. Lentil seeds contain high levels of protein, including the essential amino acids - isoleucine and lysine, and unlike meat, poultry, fish and eggs, this protein source contains no cholesterol and virtually no fat. Lentil is also eaten with a grain such as rice, wheat or barley, provides all the essential amino acids. Lentil is believed to encourage the flow of milk and it is also a nutritious fodder for animals.

Lentil is having potential to grow under dry land areas. It is also used as a cover crop to check the soil erosion and is grown throughout the northern and central India. In India, it occupies an area of 1.48 m ha and contributes 1.03 m t to pulse production with productivity of 697 kg ha^{-1}. It is mainly cultivated in Madhya Pradesh, Uttar Pradesh, Bihar, and West Bengal, which account for 85 per cent of total production (Anon., 2015). One of the important reasons for unstable lentil yield is the indeterminate growth habit of plants. Extensive vegetative growth, lodging, pod abortion due to limited light interception in the lower part of the canopy, excessive flower and pod shedding, and competition between pods and vegetative parts for photosynthates are all the consequences of indeterminacy and late maturity. There are enough evidences to show that lentil could be adapted and grown well in Karnataka as it is being grown in Belagavi district followed by *kharif* paddy using local varieties. As lentil is drought tolerant, it has an ample scope for cultivation in Northern Dry Zone of Karnataka. Keeping these points in view, the field experiment was planned with the objective to identify the profitable combination of lentil genotype, seed rate and fertilizer level for higher productivity.

Material and methods

A field experiment was conducted at Regional Agricultural Research Station, Vijayapura in Northern dry zone of Karnataka to study the response of lentil (*Lens culinaris* Medik.) genotypes to seed rate and fertilizer levels 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 crop field was applied with nitrogen, phosphorus and potassium in the form of urea, di-ammonium phosphate and muriate of potash as per the treatments as entire basal dose. Fertilizers were applied manually adjacent to the seed line and covered with soil to avoid the losses. The crop was sown with 30 cm row spacing in medium deep black soil 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. However, life saving irrigation was provided to the crop. 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

The lentil genotype, RVL 31 recorded significan tly higher grain yield (130.7 kg ha^{-1}) and was on par with genotype JL 3 (121.0 kg ha^{-1}). The yield increase was 261 per cent and 242 per cent, compared to genotype IPL 316 (50.0 kg ha^{-1}), respectively.

Significantly higher grain yield of genotype RVL 31 and JL 3 was attributed to significantly higher growth and yield parameters *viz.,* total dry matter accumulation per plant at harvest (1.30 and 1.36 g plant^{-1}, respectively), pods per plant (13.65 and 17.20, respectively), seeds per pod (1.06 and 1.07, respectively), and harvest index (19.25% and 16.39%, respectively). Similar findings of higher grain yield in lentil genotypes were reported by Singh *et al.* (2011) and Rahman *et al.* (2013) due to higher growth and yield parameters.

The significantly least grain yield recorded with genotype IPL 316 (50.0 kg ha^{-1}) was due to significantly longer crop duration, significantly lower growth and yield parameters *viz.,* total dry matter accumulation per plant at harvest (6.12 g plant^{-1}) and pods per plant (12.95) This indicates that due to longer crop duration, it suffered from moisture stress at reproductive phase compared to other genotypes. The higher temperature and moisture stress at reproductive phase resulted in less remobilization. Lentil crop essentially requires cooler temperature for its growth and development. Due to change in weather parameters *i.e.,* shorter winter period which 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.

The genotype, IPL 316 accounted for significantly higher haulm yield (817.2 kg ha^{-1}) compared to other genotypes. The

Table 1. Growth and yield parameters of lentil genotypes as influenced by seed rate and fertilizer levels under protective irrigation

Treatment	Plants per m row length at harvest	Dry matter production (g plant^{-1})		Pods plant^{-1}	Seeds pod^{-1}
		60 DAS	At harvest		
Genotypes (G)					
G_1	25.0^{a}	0.34^{b}	1.36^{a}	17.2^{a}	1.07^{a}
G_2	24.4^{a}	0.36^{a}	1.19^{b}	13.0^{a}	1.05^{c}
G_3	26.0^{a}	0.32^{c}	1.30^{ab}	13.7^{a}	1.06^{b}
S.Em±	0.76	0.014	0.037	1.19	0.013
Seed rate (S)					
S_1	20.9^{c}	0.40^{a}	1.61^{a}	18.1^{a}	1.08^{a}
S_2	25.2^{b}	0.33^{b}	1.30^{b}	13.5^{b}	1.07^{b}
S_3	29.2^{a}	0.29^{c}	0.94^{c}	12.2^{b}	1.04^{c}
S.Em±	1.06	0.007	0.081	0.76	0.008
Fertilizer levels (F)					
F_1	26.3^{a}	0.37^{a}	1.51^{a}	17.0^{a}	1.08^{a}
F_2	24.0^{b}	0.31^{b}	1.06^{b}	12.2^{b}	1.04^{b}
S.Em±	0.52	0.012	0.040	0.72	0.007
Interaction (G×S×F)					
$G_1S_1F_1$	21.7^{d-g}	0.52^{a}	2.15^{a}	22.1^{a}	1.14^{a}
$G_1S_1F_2$	20.2^{fg}	0.37^{de}	1.23^{c-g}	18.9^{a-c}	1.06^{de}
$G_1S_2F_1$	26.8^{a-d}	0.34^{g}	1.91^{ab}	19.1^{a-c}	1.09^{b}
$G_1S_2F_2$	23.3^{c-g}	0.26^{j}	1.00^{f-h}	13.1^{b-e}	1.06^{de}
$G_1S_3F_1$	30.8^{a}	0.28^{i}	1.07^{e-h}	17.0^{a-d}	1.06^{de}
$G_1S_3F_2$	27.3^{a-c}	0.27^{ij}	0.83^{h}	13.0^{b-e}	1.03^{gh}
$G_2S_1F_1$	21.5^{e-g}	0.46^{b}	1.58^{bc}	19.4^{ab}	1.08^{bc}
$G_2S_1F_2$	19.3^{g}	0.37^{de}	1.33^{c-f}	12.4^{b-e}	1.06^{de}
$G_2S_2F_1$	26.2^{a-e}	0.40^{c}	1.32^{c-f}	14.6^{b-e}	1.07^{cd}
$G_2S_2F_2$	22.8^{e-g}	0.36^{ef}	1.06^{e-h}	9.8^{de}	1.04^{fg}
$G_2S_3F_1$	29.3^{ab}	0.31^{b}	0.97^{f-h}	12.3^{b-e}	1.05^{ef}
$G_2S_3F_2$	27.2^{a-c}	0.26^{j}	0.88^{gh}	9.2^{e}	1.02^{h}
$G_3S_1F_1$	21.8^{d-g}	0.38^{d}	1.96^{a}	23.7^{a}	1.09^{b}
$G_3S_1F_2$	21.2^{e-f}	0.31^{h}	1.40^{c-e}	12.1^{b-e}	1.04^{fg}
$G_3S_2F_1$	27.2^{a-c}	0.35^{fg}	1.50^{cd}	13.2^{b-e}	1.09^{b}
$G_3S_2F_2$	25.2^{b-f}	0.27^{ij}	1.01^{e-h}	11.3^{de}	1.05^{ef}
$G_3S_3F_1$	31.3^{a}	0.32^{h}	1.13^{d-h}	11.9^{c-e}	1.05^{ef}
$G_3S_3F_2$	29.2^{ab}	0.28^{i}	0.79^{h}	9.7^{de}	1.04^{fg}
S.Em±	1.56	0.037	0.121	2.17	0.020

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}

haulm yield increase was 30.8 per cent over RVL 31 and 19.5 per cent over JL 3. This was also due to more vegetative growth because of longer crop duration and lower grain yield due to moisture stress at later period. The results are in conformity with the findings of Abdellah *et al.* (1990).

Effect of seed rate

The lentil crop sown with the seed rate of 40 kg ha^{-1} recorded significantly higher grain yield (135.2 kg ha^{-1}) compared to other two seed rates. The yield increase was 54.9 per cent over 35 kg ha^{-1} seed rate and 70.7 per cent over 30 kg ha^{-1}. This was due to significantly higher number of plants per m row length at harvest (29.2) and harvest index (16.63%). The results are in conformity with the findings of Wall (1994), Singh *et al.* (2005), Parveen and Bhuiya (2010), Saleem *et al.* (2012) and Eriksmoen *et al.* (2013) who also reported positive correlation of seed yield with seed rate.

The significantly lowest grain 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 harvest (20.9). However, it recorded significantly higher growth and yield parameters *viz.,* total dry matter accumulation per at 60 DAS and harvest (0.40 and 1.61 g plant^{-1}, respectively), pods per plant (18.10), seeds per pod (1.08), seed yield per plant (0.44 g). The better per plant performance was due to better utilization of resources. Despite significantly higher growth and yield parameters per plant, the reduction in grain yield compared to higher seed rate of 35 and 40 kg ha^{-1} was mainly due to lower plant population per unit area. These results are in conformity with the findings of Praveen and Bhuiya (2010) who was also reported that, the seed rate of 30 kg ha^{-1} recorded better growth and yield parameters but the reduction in grain yield compared to higher seed rate of 60 kg ha^{-1} was mainly due to lower plant population per unit area.

Effect of fertilizer levels

Among the various fertilizer levels, 25:50:25 kg N, P_2O_5 and K_2O ha^{-1} recorded significantly higher grain yield (123.2 kg ha^{-1}) compared to the fertilizer level of 10:30:00 kg N,

Table 2. Yield parameters, yield and harvest index of lentil genotypes as influenced by seed rate and fertilizer levels under protective irrigation

Treatment	Seed yield plant^{-1} (g)	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
Genotypes (G)				
G_1	0.48^{a}	121.0^{a}	655.3^{b}	16.39^{a}
G_2	0.33^{a}	50.0^{b}	817.2^{a}	6.11^{b}
G_3	0.34^{a}	130.7^{a}	653.5^{b}	19.25^{a}
S.Em$\pm$	0.048	3.26	1.26	0.829
Seed rate (S)				
S_1	0.44^{a}	79.2^{b}	599.1^{c}	11.09^{b}
S_2	0.38^{b}	87.3^{b}	709.0^{b}	13.37^{ab}
S_3	0.32^{c}	135.2^{a}	817.9^{a}	17.30^{a}
S.Em$\pm$	0.016	5.65	0.99	1.219
Fertilizer levels (F)				
F_1	0.45^{a}	123.2^{a}	801.3^{a}	15.95^{a}
F_2	0.32^{b}	78.0^{b}	616.0^{b}	11.88^{b}
S.Em$\pm$	0.027	3.68	0.80	1.032
Interaction (G×S×F)				
$G_1S_1F_1$	0.63^{a}	112.7^{cd}	711.4^{i}	14.14^{b-g}
$G_1S_1F_2$	0.48^{a-c}	83.5^{de}	425.9^{n}	13.44^{b-g}
$G_1S_2F_1$	0.59^{ab}	138.3^{c}	761.2^{f}	16.89^{b-f}
$G_1S_2F_2$	0.36^{a-c}	74.9^{ef}	519.1^{l}	12.69^{c-g}
$G_1S_3F_1$	0.49^{a-c}	191.0^{b}	801.1^{d}	23.14^{a-c}
$G_1S_3F_2$	0.32^{bc}	125.7^{c}	713.3^{i}	18.02^{b-e}
$G_2S_1F_1$	0.47^{a-c}	48.1^{ef}	714.7^{i}	4.92^{g}
$G_2S_1F_2$	0.34^{bc}	42.2^{f}	672.1^{j}	4.47^{g}
$G_2S_2F_1$	0.40^{a-c}	51.5^{ef}	944.8^{a}	7.00^{fg}
$G_2S_2F_2$	0.25^{c}	44.0^{f}	836.0^{c}	6.33^{g}
$G_2S_3F_1$	0.29^{c}	67.1^{ef}	951.9^{a}	8.08^{e-g}
$G_2S_3F_2$	0.25^{c}	47.3^{ef}	783.9^{e}	5.87^{g}
$G_3S_1F_1$	0.45^{a-c}	116.0^{cd}	642.8^{k}	17.45^{b-f}
$G_3S_1F_2$	0.30^{c}	72.6^{ef}	427.5^{n}	12.12^{d-g}
$G_3S_2F_1$	0.41^{a-c}	140.4^{c}	751.1^{g}	23.77^{ab}
$G_3S_2F_2$	0.30^{c}	74.9^{ef}	442.0^{m}	13.52^{b-g}
$G_3S_3F_1$	0.33^{bc}	243.4^{a}	933.0^{b}	28.20^{a}
$G_3S_3F_2$	0.27^{c}	136.6^{c}	724.4^{h}	20.47^{a-d}
S.Em$\pm$	0.082	11.05	2.42	3.097

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}

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 yield parameters *viz.,* plants per m row length at harvest (26.8), dry matter accumulation per plant at 60 DAS and harvest (0.37 and 1.51 g $plant^{-1}$, respectively), pods per plant (17.03), seeds per pod (1.08), seed yield per plant (0.45 g), haulm yield (801.2 kg ha^{-1}) and harvest index (15.95 %). Singh *et al.* (2011) 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 Niri *et al.* (2010), Hussain *et al.* (2011), Rahman, *et al.* (2013) and Choubey *et al.* (2013).

Interaction effect of genotype, seed rate and fertilizer levels

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 grain yield (243.4 kg ha^{-1}) over rest of the interactions. The yield increase was 414.58 per cent over the interaction $G_2S_3F_2$ *i.e.*, genotype IPL 316 with seed rate of 40 kg ha^{-1} and fertilizer level of 10:30:00 kg N, P_2O_5 and K_2O ha^{-1} (47.3 kg ha^{-1}). 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 at harvest (31.3) resulted in significantly higher yield. The significantly higher performance of individual effect of genotype (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 findings of Saleem *et al.* (2012), Eriksmoen *et al.* (2013) and Rahman *et al.* (2013).

The next best significantly higher interaction for grain yield (191.0 kg ha^{-1}) was with interaction $G_1S_3F_1$ *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}. This was due to significantly higher number of plants per m row length at harvest (30.8) compared to other interactions, except the interaction $G_3S_3F_1$. The individual factors in this interaction were also significantly higher contributing to higher yields. These findings are in conformity with Saleem, *et al.* (2012), Eriksmoen *et al.* (2013) and Rahman *et al.* (2013) who also reported that seed yields increased incrementally as seeding rates and fertilizer levels were increased.

Significantly lower grain yield was recorded with interaction $G_2S_1F_2$ *i.e.,* genotype IPL 316 with lower level seed rate of 30 kg ha^{-1} and lower fertilizer level of 10:30:00 kg N, P_2O_5 and K_2O ha^{-1} (42.2 kg ha^{-1}). This was mainly due to significantly lower number of plants per m row length at harvest (19.3) and significantly lower performance of individual factors for grain yield in this interaction.

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} found optimum for higher grain yield (243.4 kg ha^{-1}) with better growth and yield parameters in Northern dry zone of Karnataka during *rabi* season.

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