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To study the interaction between dates of planting and genotypes on growth, yield attributes and yield of lentil

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Abstract
The investigation entitled "Performance of lentil genotypes under delayed planting condition in *Vertisols* of Chhattisgarh plains" was conducted out at Instructional cum Research Farm, IGKV, Raipur, (C. G.) during *rabi* 2020-21. The experiment was performed in the Factorial Randomized Block Design with three replications. The treatments comprised of three planting time *viz.* D_1: 20th November (timely), D_2: 30th November (late) and D_3: 10th December (very late) and five genotypes *viz.* V_1: JL-3, V_2: RKL58F3715, V_3: L-4076, V_4: CG Masoor 1 and V_5: DPL-62. Results revealed that genotype RKL58F3715 gave highest yield (1433 kg ha^{-1}) followed by CG Masoor 1 (1276 kg /ha). The economic returns from the genotypes RKL58F3715 and CG Masoor 1 (63075 Rs. /ha and 54359 Rs. /ha, respectively) were also higher than others. Among the interaction effect between planting time and genotypes, genotype RKL58F3715 sown up to 20th November fetched significantly maximum grain yield (1765 kg /ha) and economic returns (81946 Rs. /ha) closely followed by CG Masoor 1 (1732 kg /ha & 80091 Rs. /ha, respectively) over other treatment combinations.

Keywords: Genotype, date of planting, growth, lentil, yield

Introduction
Pulses rank as the 2nd most important food crops followed by cereals and are the main source of vegetable protein. India stands as the largest producer and consumer of pulses globally encompassing 33% of the global area and 22% of the global production. The area under pulses in India during 2019-2020 is around 279.9 lakh ha with total production of 230.3 lakh tonnes and average productivity of 823 kg ha^{-1} (Anonymous, 2020) [5]. The area under lentil in Chhattisgarh state is around 138 hundred ha with total production of 45 hundred tonnes and average yield of 323 kg /ha. Although, India being the prime pulse crop growing country in the world, however, pulses contributed only 6-7% to total food grain production of the country. Pulses supplied protein, energy, dietary fibre, vitamins and minerals required for human health. It supplies 25 percentages of protein requirements of mostly vegetarian population and 14 per cent of total protein of an Indian diet. In comparison to other vegetables, pulses are wealthy in protein and contribute about 10 per cent of protein intake in daily basis and 5% of energy intake.
Lentil (*Lens culinaris* Medik.) is one of the most important pulse crops. It is usually consumed as a seed (full decorticated, decorticated and split). It is also processed into flour to make variety of dishes. In Indian sub-continent, it is generally ingested as *daal* (seeds boiled and mashed into soup). It is also utilized in making of various types of snacks and sweets. The straw has also high nutritive value. De-hulled lentil seeds contain 25 to 26% protein, 1.2-1.3% fat, 3.2% fibre and 55-57% carbohydrate. It is having good content of Ca (68 mg 100 g seed^{-1}), P (300 mg100 g seed^{-1}) and Fe (7 mg100 g seed^{-1}). It is also abundant in vitamin C and riboflavin.
The planting date is the key factor of productivity as it directly influences lentil growth and development through environmental modifications and photo-thermo-sensitive effects. In conditions of delayed planting, the growing season, especially from flowering to maturity, is shortened due to the accelerated maturation of the crop. Consequently, late-planted lentil crops exhibit decreased yields compared to those planted timely. Understanding how different varieties respond to planting dates is of paramount importance, given that cultivars exhibit varying growth and development behaviours in distinct agro-ecological conditions. In India, the majority of lentil plantings experience delays because of late harvesting of the preceding *kharif* crop, often paddy.

Consequently, when lentils are cultivated after paddy in the *kharif* season, farmers may struggle to sow a summer crop on schedule. Additionally, the lentil crop is susceptible to heat stress during the seed-filling stage in many cultivated areas, leading to reduced yields. With the growing season being significantly shortened, the adoption of early-maturing cultivars becomes crucial in India. Extra-early lentil varieties have the potential to enable the cultivation of an additional crop in the succeeding season, addressing concerns about potential yields. (Mandi *et al.* 2015) [13].

The optimal date for sowing aids in determining the best period for germination, establishment and canopy development (Bussmann *et al.* 2016 and Dennett *et al.* 1999) [7, 8]. The early planted crop exhibits vigorous growth, but this is later followed by a decrease in both pod and seed production, ultimately constraining overall yield. Late sowing also results in a poor productivity, slowed growth, and a shorter seed development period (Girma *et al*. 2017 and Mubvuma *et al*. 2015) [10, 18].

Materials and Methods

The experiment "Performance of lentil genotypes under delayed planting condition in *Vertisols* of Chhattisgarh plains" was performed at Agriculture Instructional-cum-research Farm, IGKV, Raipur, (C G) during *rabi* season 2020-21. The region experiences a sub-humid to semi-arid climate, while the experimental plot consisted of *Vertisols* characterized by varying levels of N, P_2O_5, and K_2O ranging from low to high, and maintained a neutral pH. The experiment was carried out in the Factorial Randomized Block Design (FRBD) with 3 replications. The treatments consisted of 3 planting time *viz*. D_1: 20th November (timely), D_2: 30th November (late) and D_3: 10th December (very late) and five genotypes *viz*. V_1: JL-3, V_2: RKL58F3715, V_3: L-4076, V_4: CG Masoor 1 and V_5: DPL-62. Lentil genotypes were sown on 20th November, 30th November and 10th December, 2020 and harvested on 6th March and 11th March, 2021. During crop growth period various yield attributing parameters like pods/ plant, seeds/ pod, seed index, seed and stover yield were taken as per plan and requirement of study.

Results and Discussion

Number of pods plant^{-1}

Among the genotypes of lentil, RKL58F3715 recorded significantly superior number of pods plant^{-1} (55) as compared to other genotypes. Whereas, the minimum number of pods plant^{-1} was recorded under genotype DPL-62 (37). Number of pods plant^{-1} varied might be due to genetic characteristics of various genotypes. Roy *et al.* (2009) [25], Sen *et al.* (2016) [27], Redemma *et al.* (2019) [43] and Mule *et al.* (2020) [38-39].

In terms of planting date, it's noteworthy that the 20th of November yielded a significantly higher number of pods per plant (50) compared to the other planting dates, whereas the lowest number of pods per plant (40) was recorded for the 10th of December planting date. Highest number of pods plant^{-1} in timely date of planting may be due to higher number of branches plant^{-1} and number of flowers plant^{-1} with ample supply of soil moisture and nutrients. Rahman *et al.* (2002) [23], Ramroodi *et al.* (2008) [24], Moosavi *et al.* (2014) [17] Umer (2015) [30], Waheed *et al.* (2015) [47], Ouji and Mouelhi (2017) [19], Kumar *et al.* (2018) [36], Yadav *et al.* (2018) [48] and Mule *et al.* (2020) [38-39].

The interaction between date of planting and genotypes revealed that sowing of genotype RKL58F3715 at all the date of planting produced significantly superior number of pods plant^{-1} than other combination of date of planting and genotypes. RKL58F3715 when sown on 20th November recorded significantly higher number of pods plant^{-1} (61) than other genotypes either sown on the same date of planting or later dates of planting *i.e.* 30th November or 10th December. Ramroodi *et al.* (2008) [24], Mumtaz *et al.* (2015) [40], Ali *et al.* (2016) [33] and Baidya *et al.* (2018) [6].

Number of seeds pod^{-1}

Number of seeds pod^{-1} showed non-significant variation with respect to genotypes. Among the lentil genotypes, RKL58F3715 and CG Masoor 1 recorded numerically highest number of seeds pod^{-1} (1.96) than rest of the genotypes. On the other hand, L-4076 recorded the lowest number of seeds pod^{-1} (1.84). Redemma *et al.* (2019) [43] and Mule *et al.* (2020) [38-39].

Number of seeds pod^{-1} showed non-significant variation with respect to date of planting whereas, maximum numerical value of number of seeds pod^{-1} (1.99) was recorded in timely date of planting *i.e.* 20th November. The crop enjoyed on an average 117 days growth period under timely planting. The crop duration for later planting dates shrinked gradually as the planting was delayed. Higher number of seeds per pod have been due to relatively longer crop duration and within it more number of days for reproductive phase in timely date of planting as compared to later date of planting. It may be concluded from the experiments that the timely planting of lentil gave the higher number of seeds pod^{-1}. Umer (2015) [30], Waheed *et al.* (2015) [47], Kundu *et al.* (2016) [37], Samant and Mohanty (2017) [45] and Mule *et al.* (2020) [38-39].

Number of seeds per plant^{-1}

Among the lentil genotypes, RKL58F3715 recorded significantly higher number of seeds plant^{-1} (108.1) as compared to other genotypes. On the other hand, DPL-62 recorded the lowest number of seeds plant^{-1} (73.5). Similar findings were noted by Ali *et al.* (2018) [4].

As regards to date of planting, all the three dates under study resulted in significant difference in number of seeds plant^{-1}. 20th November date of planting recorded significantly higher number of seeds plant^{-1} (96.2) than other date of planting. However, the lowest number of seeds plant^{-1} (75.4) was obtained with 10th December date of planting. Similar observations were noted by Ramroodi *et al.* (2008) [24], Cossani *et al.* (2017), Mehraban (2017) [15], Raja *et al.* (2017) and Rafat *et al.* (2021) [42, 41].

100-seed weight (g)

Among various lentil genotypes, DPL-62 recorded significantly higher 100-seed weight (3.20 g) which was at par with CG Masoor 1 (3.16) and L4076 (3.11). On the other hand, JL-3 recorded the lowest 100-seed weight (2.79 g). This might be due to varietal characteristics of the genotypes. Similar results have also been reported by Yadav *et al.* (2017) [33], Ali *et al.* (2018) [4], Redemma *et al.* (2019) [43], Mule *et al.* (2020) [38-39] and Pamei *et al.* (2020) [20].

The data clearly reveals that date of planting had no effect on the 100-seed weight. However, numerically heaviest grains were recorded with 20th November date of planting (3.08 g) followed by 30th November (3.06 g) and 10th December (2.99 g).

Seed yield (kg ha^{-1})

Among the lentil genotypes, RKL58F3715 produced significantly higher seed yield (1433 kg ha^{-1}) than the rest of the genotypes. However, lowest seed yield was obtained under genotype DPL-62 (837 kg ha^{-1}). Higher seed yield in genotype RKL58F3715 might be due to more number of pods plant^{-1}, seeds pod^{-1} and seeds plant^{-1}. Roy *et al.* (2009) [25], Dogan *et al.* (2014) [9], Sen *et al.* (2016) [27], Mehraban (2017) [15], Sarker *et al.* (2017) [46], Ali *et al.* (2018) [4], Khayat *et al.* (2018) [35], Patil *et al.* (2018) [21], Woldeselassie and Admasu (2018) [32], Redemma *et al.* (2019) [43], Singh *et al.* (2019) [29], Ahmed *et al.* (2020) [1] and Mule *et al.* (2020) [38-39].

The highest seed yield (1355 kg ha^{-1}) was obtained with 20th November date of planting which was significantly superior to rest of two planting dates. However, the lowest seed yield (861 kg ha^{-1}) was noted with 10th December date of planting. All the date of planting differed significantly from each other and the order of their descendance for seed yield was 20th November> 30th November> 10th December. Redemma *et al.* (2019) [43], Singh *et al.* (2019) [29], Amiri *et al.* (2020) [34], Mule *et al.* (2020) [38-39], Saha *et al.* (2020) [1], Sarkar *et al.* (2020) [26] and Rafat *et al.* (2021) [41].

Genotype RKL58F3715 sown on 20th November date of planting recorded significantly higher seed yield (1765 kg ha^{-1}) being on par to CG Masoor 1 (1732 kg ha^{-1}) over rest of the treatment combinations. On 10th December date of planting, genotype RKL58F3715 recorded significantly higher seed yield (1082 kg ha^{-1}) than other genotypes planted on this date. Lentil genotype RKL58F3715 showed significantly higher seed yield in combination with all the date of planting as compared to combination of other genotypes and date of planting. Akhter *et al.* (2013) [2], Rehman *et al.* (2015) [44], Ali *et al.* (2016) [33], Sen *et al.* (2016) [27], Alam *et al.* (2017) [3], Kumar *et al.* (2017) [33], Ali *et al.* (2018) [4], Khayat *et al.* (2018) [35], Patil *et al.* (2018) [21], Redemma *et al.* (2019) [43], Ahmed *et al.* (2020) [1] and Singh *et al.* (2020) [28].

Stover yield (kg ha^{-1})

Among various lentil genotypes, RKL58F3715 produced significantly higher stover yield (2651 kg ha^{-1}) than rest of the genotypes. On the other hand, the lowest stover yield was obtained under genotype DPL-62 (1544 kg ha^{-1}). Similar findings have been reported by Ali *et al.* (2018) [4], Redemma *et al.* (2019) [43], Ahmed *et al.* (2020) [1] and Mule *et al.* (2020) [38-39]

The highest stover yield (2508 kg ha^{-1}) was obtained with 20th November date of planting which was significantly superior over rest of two planting dates. The lowest stover yield (1591 kg ha^{-1}) was noted with 10th December date of planting. Mule *et al.* (2020) [38-39] and Sarkar *et al.* (2020) [26].

Genotype RKL58F3715 recorded significantly higher stover yield under all the date of planting over rest of the treatment combinations. At 20th November date of planting, genotype RKL58F3715 recorded significantly higher stover yield (3270 kg ha^{-1}) over rest of the treatment combinations but, it was statistically at par to CG Masoor 1 (3200 kg ha^{-1}) sown on the same date. On the other hand, genotype DPL-62 sown on 30th November produced the lowest stover yield (1243 kg ha^{-1}). Ramroodi *et al.* (2008) [24] Redemma *et al.* (2019) [43] and Singh *et al.* (2020) [28].

Harvest Index (%)

Among the genotypes DPL-62 gave the numerically highest value of harvest index (35.14%). The lowest harvest index was noted under genotype JL-3 (35.06%). Similar findings have been reported by Ali *et al.* (2018) [4] and Redemma *et al.* (2019) [43].

Numerically, the highest harvest index (35.12%) was noted under 30th November date of planting. Whereas, the lowest harvest index (35.06%) was noted under 20th November date of planting. All the date of planting differed from each other and the order of their descendance for harvest index (%) was 30th November>10th December>20th November. The results of this experiment represents the genuine relationship between vegetative growth and HI as due to higher temperature resulted greater vegetative growth and hence delayed sown (late and very late) genotypes depicted higher estimates of harvest index. Similar findings have been reported by Ramroodi *et al.* (2008) [24].

Table 1: Yield attributing characters of lentil as affected by genotypes and date of planting

Treatment	Number of pods plant^{-1}	Number of seeds pod^{-1}	Number of seeds plant^{-1}	100 seed weight (g)
Genotypes JL 3	41	1.85	75.9	2.79
RKL58F3715	55	1.96	108.1	2.96
L4076	42	1.84	80.9	3.11
CG Masoor 1	51	1.96	96.8	3.16
DPL 62	37	1.91	73.5	3.20
S.Em ±	1.20	0.07	2.70	0.05
C.D. (P = 0.05)	3.48	NS	7.83	0.14
Date of planting				
20 November	50	1.99	96.2	3.08
30 November	46	1.88	89.5	3.06
10 December	40	1.85	75.4	2.99
S.Em ±	0.93	0.06	2.1	0.04
C.D. (P = 0.05)	2.70	NS	6.1	NS

Table 2: Number of pods plant^{-1} of lentil as affected by interaction between date of planting and genotypes

Treatment	Number of pods plant^{-1}			
	Date of planting			Mean
	20 November	30 November	10 December	
Genotypes				
JL 3	41	40	43	**41.0**
RKL 58F3715	61	57	47	**55.1**
L 4076	45	48	34	**42.1**
CG Masoor 1	61	50	43	**51.2**
DPL 62	44	34	33	**37.1**
Mean	50.3	45.7	39.9	
		Genotypes	**Date of planting**	**Interaction**
S.Em ±		1.2	0.9	2.1
C.D. (P = 0.05)		3.5	2.7	6.0

Table 3: Seed yield (kg ha^{-1}), Stover yield (kg ha^{-1}) and Harvest index (%) of lentil as affected by genotypes and date of planting

Treatment	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Genotypes JL 3	987	1828	35.06
RKL58F3715	1433	2651	35.09
L4076	1026	1898	35.10
CG Masoor 1	1276	2360	35.09
DPL 62	837	1544	35.14
S.Em ±	43	79	0.03
C.D. (P = 0.05)	124	228	NS
Date of planting			
20 November	1355	2508	35.06
30 November	1120	2069	35.12
10 December	861	1591	35.11
S.Em ±	33	61	0.03
C.D. (P = 0.05)	96	176	NS

Table 4: Seed yield (kg ha^{-1}) of lentil as affected by interaction between date of planting and genotypes

Treatment	Seed yield (kg ha^{-1})			
	Date of planting			Mean
	20 November	30 November	10 December	
Genotypes				
JL 3	1002	893	1067	987
RKL 58F3715	1765	1452	1082	1433
L 4076	1151	1182	746	1026
CG Masoor 1	1732	1399	697	1276

Table 5: Stover yield (kg ha^{-1}) of lentil as affected by interaction between date of planting and genotypes

Treatment	Stover yield (kg ha^{-1})			
	Date of planting			Mean
	20 November	30 November	10 December	
Genotypes				
JL 3	1865	1650	1969	1828
RKL 58F3715	3270	2683	2000	2651
L 4076	2133	2182	1378	1898
CG Masoor 1	3200	2587	1292	2360
DPL 62	2074	1243	1315	1544
Mean	2508	2069	1591	
		Genotypes	Date of planting	Interaction
S.Em ±		79	61	136
C.D. (P = 0.05)		228	176	394

Conclusion

Based on the findings of this experiment it may be concluded that lentil genotype RKL58F3715 out yielded (1433 kg ha^{-1}) other genotypes and fetched maximum economic returns (Rs. 63075 ha^{-1}). However, genotype CG Masoor 1 (1276 kg ha^{-1} and Rs. 54359 ha^{-1}, respectively) also performed better under the agro climatic condition of Chhattisgarh Plains. Timely date of planting *i.e.* 20th November produced maximum seed yield (1355 kg ha^{-1}) and economic returns (Rs. 58618 ha^{-1}) from lentil. Among the interaction effect between date of planting and genotypes, RKL58F3715 sown up to 20th November fetched significantly maximum grain yield (1765 kg ha^{-1}) and economic returns (Rs. 81946 ha^{-1}) closely followed by CG Masoor 1 (1732 kg ha^{-1} and Rs. 80091 ha^{-1}, respectively) as compared to rest of the treatment combinations.

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