Research Article

# Impact of Row Spacing on the Growth and Yield Parameters of Lentil (*Lens culinaris* L) under Semi-arid Region of Pakistan

**Mohammad Mohsin Faqeer[1], Muhammad Aquil Siddiqui[2]*, Nighat Seema Soomro[1], Shameem Raja[3], Muhammad Tahir Khan[2], Ghulam Shah Nizamani[2], Fareen Deeba Soomro[4] and Muhammad Mahran Aslam[2]**

*[1]Department of Agronomy, Sindh Agriculture University, Tando Jam, Pakistan; [2]Nuclear Institute of agriculture, Tando Jam, Pakistan; [3]Department of Botany, Government College Women University, Faisalabad, Pakistan; [4]Department of Zoology University of Sindh Jamshoro, Papkistan.*

**Abstract** | Lentil is an important annual legume crop in the semi-arid regions of Pakistan. The current two years study was conducted to determine the impact of row spacing on the growth and yield parameters of lentil varieties. Three lentil genotypes (M-85, NIA Masoor 2005 and NIA Masoor 2016) were evaluated at three spacing treatments (15, 30 and 45 cm) under the RCBD. The morphological characteristics of lentil genotypes depicted that maximum germination, plant height, number of branches plant$^{-1}$, number of pods plant$^{-1}$, weight of 1000 seeds, seed yield, and early days to maturity were observed at 30 cm row spacing. Interaction of varieties x row spacing indicated that NIA Masoor 2016 showed the best performance at 30 cm row spacing. This genotype exhibited highest germination (97.02 %), plant height (41.17 cm), number branches per plant (7.53), number of pods per plant (54.93), number of seeds per plant (2.75), 1000 seed weight (60.09 g), and seed yield (1863.6 kg ha$^{-1}$) at 30 cm row spacing. The results of the current study can be used for optimal lentil production for enhancing lentil yield in Pakistan.

**Received** | July 23, 2020; **Accepted** | October 08, 2020; **Published** | December 31, 2020
***Correspondence** | Muhammad Aquil Siddiqui, Nuclear Institute of agriculture, Tando Jam, Pakistan; **Email:** siddiqui_aquil@yahoo.com
**Citation** | Faqeer, M.M., M.A. Siddiqui, N.S. Soomro, S. Raja, M.T. Khan, G.S. Nizamani, F.D. Soomro and M.M. Aslam. 2020. Impact of row spacing on the growth and yield parameters of lentil (*Lens culinaris* L) under semi-arid region of Pakistan. *Pakistan Journal of Agricultural Research*, 33(4): 945-950.
**DOI** | http://dx.doi.org/10.17582/journal.pjar/2020/33.4.945.950
**Keywords** | Row spacing's, Yield, Yield components, Lentil varieties, Masoor

## Introduction

Lentil (*Lens culinaris* Medik) is important pulse crop which is mainly cultivated rainfed as well as irrigated areas of Pakistan. Lentil is the second leading legume crop grown in Pakistan and sown as Rabi season (Ayub *et al*., 2001). The lentil production was 6.4 thousand tons with 523 kg ha$^{-1}$ yield during 2018-19 (FAO, 2019). Pulses are regarded as "the poor man's meat" due to the fact none the less pulses are the cheapest source of protein (Akter and Fahmida 2016). The available lentil germplasm has not been evaluated for yield and yield related traits (Nourin *et al*., 2019).

The proper row spacing can make certain appropriate growth of the above ground and underground parts of the plant through well-organized use of solar radiation, nutrients, water, land as well as air spaces and row spacing for sowing is recommended to maintain the required number of plant populations and to undertake intercultural operations for harvesting a superior yield (Ouji *et al*., 2016). Yield of lentil can be increased with sowing time and proper row spacing

(Singh *et al.*, 2009). Researchers indicated that the seed yield of lentil planted with narrow row spacing of 30 cm produced maximum seed yield than the wider row spacing's of 70 cm (Khan *et al.*, 2001) The acceptance of better techniques with planting time, row spacing and higher yielding varieties may improve seed yield production in lentil. On the other hand, the plants unable to use resource efficiently when grown low and scatteredly planted which ultimately produced low yield. The present experiment designed to determine the appropriate row spacing to maintain plant population and economic yield under semi-arid region.

## Materials and Methods

Field trial was conducted at Nuclear Institute of Agriculture, Tando Jam, Pakistan to assess impact of row spacing on the growth and yield on lentil varieties. The field trial was conducted with randomized complete block design (RCBD), replicated three times and plot size was 5 m x 5 m = ($25m^{-2}$). No fertilizer or pesticide was applied considering the soil and plant health. Mean monthly rainfall received during the crop season in each of the three years was 15, 50 and 58 mm, respectively. Three lentil varieties viz. M-85, NIA, Masoor-2005, and NIA, Masoor-2016 were planted with row spacing's of 15, 30, and 45 cm and observations were recorded as germination, days to maturity, plant height, number of branches $plant^{-1}$, pods $plant^{-1}$, seeds $plant^{-1}$, 1000 seed weight (g) and seed yield (kg $ha^{-1}$). The seed was sown with single hand manual drill, and all the necessary practices were done from sowing up to harvest as the requirement of the experiment. At the time of harvesting, ten plants randomly were selected, sun-dried and threshed for yield data and agronomic traits.

### *Statistical analysis*

The experimental data were analyzed as analysis of variance (ANOVA) using MSTATC computer software. Means were compared using a least significant difference (LSD) test at the 5% level of probability (Gomez and Gomez, 1984).

## Results and Discussions

### *Germination (%)*

The maximum germination was observed at 30 cm row spacing (95.22 and 92.67 %) in varieties NIA, Masoor-2016 and NIA, Masoor-2005, while lowest germination (87.54 %) was noted in variety M-85. The results of varieties and row spacing indicated maximum germination was observed (97.02 %) at 30 cm row spacing followed by (95.85 %) at row spacing of 45 cm in NIA, Masoor-2016 and lowest germination (84.69 and 87.78 %) were observed at row spacing at 15 and 45 cm in M-85. Jamali *et al.* (2002), stated similar trend of observations were reported earlier lentil cultivars. Lentil cultivars also showed maximum germination at 30 cm followed by 45 cm while the declines in germination percentage at 15 cm or 70 cm (Table 1).

**Table 1:** *Germination (%) of lentil varieties as affected by different row spacing's.*

| Varieties | Row spacing's (cm) | | | Mean |
|---|---|---|---|---|
| | 15 | 30 | 45 | |
| M-85 | 84.69 e | 90.17 cd | 87.76 de | 87.54 b |
| NIA-Masoor-2005 | 91.41 b-d | 94.87 a-c | 91.70 b-d | 92.67 a |
| NIA-Masoor-2016 | 92.81 a-c | 97.02 a | 95.85 ab | 95.22 a |
| Mean | 89.64 b | 94.02 a | 91.77 ab | |
| Varieties SE (1.2940) (LSD (5%) (2.7432), Row spacing's SE (1.2940) (LSD (5%) (2.7432), V x RS SE (2.2413) (LSD (5%) (4.7514) | | | | |

### *Days to maturity (days)*

Table 2 indicated an early day to maturity (91.62 days) were reported in variety NIA, Masoor-2016, followed by (93.46 days) in variety M-85 while late days to maturity (96.71 days) were observed in variety NIA, Masoor-2016. The results of row spacing indicated that an early day to maturity was recorded (90.74 days) with 15 cm row spacing's and late days to maturity were obtained (96.19 days) under the row spacing's of 45 cm. Results of varieties and row spacing indicated an early days to maturity were observed (88.94 days) in variety NIA, Masoor-2016 under row spacing's of 15 cm, followed by (90.52 days) in variety M-85 under row spacing's of 15 and late days to maturity (100.75 days) were recorded in NIA, Masoor-2005 under row spacing's of 45 cm. Saxena (2009) indicated similar results were of lentil for days to maturity was affected by different spacing's and planting dates.

### *Plant height (cm)*

The maximum plant height was obtained (36.94 cm) in variety NIA, Masoor-2016, followed by (34.22 cm) in variety NIA, Masoor-2005 and minimum plant height was achieved (31.72 cm) was recorded

in variety M-85 (Table 3). Results of row spacing's indicated that the best plant height was achieved (38.61 and 35.60 cm) by row spacing of 30 cm, and minimum plant height (28.67 cm) observed under the row spacing's of 15 cm. The varieties and row spacing showed maximum plant height was obtained at par (41.17 and 39.72 cm) in varieties NIA, Masoor-2016 in row spacing's of 30 and 45 cm, followed by (38.58 cm) in variety NIA, Masoor-2005 with row spacing of 30 cm and minimum plant height was recorded (26.39 cm) in NIA, Masoor-2005 variety under row spacing of 15 cm. The similar result under row spacing had positive influence on plant height and seed yield (Singh *et al.*, 2003).

**Table 2:** *Days to maturity (days) of lentil varieties as affected by different row spacing's.*

| Varieties | Row spacing's (cm) | | | Mean |
|---|---|---|---|---|
| | 15 | 30 | 45 | |
| M-85 | 90.52 d | 92.57 cd | 97.30 ab | 93.46 b |
| NIA-Masoor-2005 | 92.76 cd | 96.64 a-c | 100.75 a | 96.71 a |
| NIA-Masoor-2016 | 88.94 d | 95.41 bc | 90.53 d | 91.62 b |
| Mean | 90.74 b | 94.87 a | 96.19 a | |
| Varieties SE (1.1317) LSD (5%) (2.3992), Row spacing's SE (1.1317) LSD (5%) (2.3992), V x RS SE (1.9602) (LSD (5%) (4.1555) | | | | |

**Table 3:** *Plant height (cm) of lentil varieties as affected by different row spacing's.*

| Varieties | Row spacing's (cm) | | | Mean |
|---|---|---|---|---|
| | 15 | 30 | 45 | |
| M-85 | 26.69 f | 36.07 c | 32.39 d | 31.72 c |
| NIA-Masoor-2005 | 29.39 e | 38.58 b | 34.69 cd | 34.22 b |
| NIA-Masoor-2016 | 29.94 e | 41.17 a | 39.72 ab | 36.94 a |
| Mean | 28.67 c | 38.61 a | 35.60 b | |
| Varieties SE (0.6683 LSD (5%) (1.1467), Row spacing's (0.6683 LSD (5%) (1.1467), V x RS SE (1.1575) LSD (5%) (2.4538) | | | | |

*Number of branches per plant*

The highest number of branches per plant were obtained (5.94) in variety NIA, Masoor-2016, followed by (4.92) in variety NIA, Masoor-2005 and lowest number of branches per plant$^{-1}$ were obtained (4.19) in variety M-85. Results of row spacing showed that number branches per plant were obtained (6.31) having 30 cm row spacing, followed by (5.34) with row spacing of 45 cm and lowest numbers of branches per plant (3.40) was observed under row spacing of 15 cm. The interaction of varieties and row spacing indicated that greatest number of branches per plant were recorded (7.53) in variety NIA, Masoor-2016 at 30 cm row spacing, followed by (6.26) in NIA, Masoor-2016 at 45 cm and lowest number of branches per plant was recorded (2.72) in M-85at 15 cm row spacing respectively (Table 4). Kalita *et al.* (2005) reported the similar trend in lentil cultivar that maximum branches per plant were achieved at 30 cm row spacing.

**Table 4:** *Number of branches plant$^{-1}$ of lentil varieties as affected by different row spacing's.*

| Varieties | Row spacing's (cm) | | | Mean |
|---|---|---|---|---|
| | 15 | 30 | 45 | |
| M-85 | 2.72 g | 5.31 c | 4.54 d | 4.19 c |
| NIA-Masoor-2005 | 3.45 f | 6.11 b | 5.21 c | 4.92 b |
| NIA-Masoor-2016 | 4.03 e | 7.53 a | 6.26 b | 5.94 a |
| Mean | 3.40 c | 6.31 a | 5.34 b | |
| Varieties SE (0.1319) LSD (5%) (0.2795), Row spacing's SE (0.1319) LSD (5%) (0.2795), V x RS SE (0.2284) LSD (5%) (0.4842) | | | | |

*Number of pods per plant*

The maximum pods per plant were obtained (49.15) in NIA, Masoor-2016, followed by (44.20) in NIA, Masoor-2005, and minimum pods per plant were recorded (37.63) in M-85. The row spacing results indicated that highest pods per plant were observed (47.38) at 30 cm followed by (44.97) at 45 cm and lowest pods per plant (38.63) at 15 cm row spacing. The maximum pods per plant were recorded (54.93 and 50.27) in NIA, Masoor-2016 at row 30 followed by (45.96) in NIA, Masoor-2005 at 45 cm and lowest per pods plant were recorded (35.39) in M-85 at 15 cm (Table 5). Seyyed *et al.* (2014) and Habib *et al.* (2006) reported that pods per plant was recorded at 30 cm row spacing which directly increased seed yield of lentil.

**Table 5:** *Number of pods plant$^{-1}$ of lentil varieties as affected by different row spacing's.*

| Varieties | Row spacing's (cm) | | | Mean |
|---|---|---|---|---|
| | 15 | 30 | 45 | |
| M-85 | 35.39 f | 38.30 e | 39.19 e | 37.63 c |
| NIA-Masoor-2005 | 38.23 e | 48.92 b | 45.46 c | 44.20 b |
| NIA-Masoor-2016 | 42.27 d | 54.93 a | 50.27 b | 49.15 a |
| Mean | 38.63 c | 47.38 a | 44.97 b | |
| Varieties SE (0.4714) LSD (5%) (0.9993), Row spacing's SE (0.4714) LSD (5%) (0.9993), V x RS SE (0.8165) LSD (5%) (1.7309) | | | | |

*Number of seeds per plant*

The greatest seeds per plant was recorded (2.46 and 2.40) in NIA, Masoor-2016 and NIA, Masoor-2005 while the lowest seeds per plant were recorded (1.57) in M-85. Row spacing results indicated that the maximum number of seeds per plant were observed (2.32) at 30 cm followed by (2.17) at 45 cm and lowest seeds per plant were recorded (2.00) at 15 cm row spacing (Table 6). Wells (1993) reported the similar results in our experiment which showed that plant spacing influenced yield and yield components on lentil.

**Table 6:** *Number of seeds plant$^{-1}$ of lentil varieties as affected by different row spacing's.*

| Varieties | Row spacing's (cm) | | | Mean |
|---|---|---|---|---|
| | 15 | 30 | 45 | |
| M-85 | 1.19 f | 1.58 e | 1.95 d | 1.57 b |
| NIA-Masoor-2005 | 2.46 a-c | 2.65 ab | 2.28 cd | 2.46 a |
| NIA-Masoor-2016 | 2.35 bc | 2.75 a | 2.29 b-d | 2.40 a |
| Mean | 2.00 b | 2.32 a | 2.17 ab | |
| Varieties SE (0.0992) LSD (5%) (0.2103), Row spacing's SE (0.0992) LSD (5%) (0.2103), V x RS SE (1.0459) LSD (5%) (2.2172) | | | | |

*Seed index (g)*

The maximum seed index was obtained in NIA, Masoor-2016 (56.07 g) followed by NIA, Masoor-2005 (48.08 g) while minimum seed index were recorded in M-85(43.32 g). The row spacing results indicated that highest seeds index (53.44 g) were achieved at 30 cm followed by (49.16) at 45 cm and lowest seed index (44.87 g) were recorded at 15 cm row spacing (Table 7). Stoilova and Pereira (1999) conducted the similar experiment and reported that weight of 1000 seeds was affected considerably under seeding densities, row spacing and seed yield.

**Table 7:** *Seed index (g) of lentil varieties as affected by different row spacing's.*

| Varieties | Row spacing's (cm) | | | Mean |
|---|---|---|---|---|
| | 15 | 30 | 45 | |
| M-85 | 41.75 d | 46.87 c | 41.34 d | 43.32 c |
| NIA-Masoor-2005 | 42.47 d | 53.36 b | 48.41 c | 48.08 b |
| NIA-Masoor-2016 | 50.39 bc | 60.09 a | 57.72 a | 56.07 a |
| Mean | 44.87 c | 53.44 a | 49.16 b | |
| Varieties SE (1.0459) LSD (5%) (2.2172), Row spacing's SE (1.0459) LSD (5%) (2.2172), V x RS SE (1.8115) LSD (5%) (3.8402) | | | | |

*Seed yield (kg ha$^{-1}$)*

The greatest seed yield were obtained in NIA, Masoor-2016 (1766.1 kg ha$^{-1}$) followed by in NIA, Masoor-2005 (1206.1 kg ha$^{-1}$) and lowest seed yield was obtained was recorded in M-85 (1088.3 kg ha$^{-1}$). Results of row spacing showed highest seed yield was obtained (1346.1, 1357.7, and 1356.7 kg ha$^{-1}$) under 15, 30, and 45 cm row spacing's. Observations of varieties and row spacing's indicated that greatest seed yield was recorded (1754.8, 1863.6 and 1679.9 kg ha$^{-1}$) in NIA, Masoor-2016 under 15, 30, 45 cm row spacing, followed by (1298.0 kg ha$^{-1}$) in NIA, Masoor-2005 at 45 cm row spacing and lowest seed yield (1026.8 kg ha$^{-1}$) were obtained in M-85 at 15 cm row spacing (Table 8). Singh *et al.* (2009) stated that seed yield increased up 10.4 % with 30 cm spacing's and 1 % more seed yield with (20 cm) row spacing's. Parveen and Bhuiya (2010) said that row spacing's is the main factor and an important part in growth and seed yield of lentil. Among factors for low yield with usual sowing methods and proper row spacing are very important in crops. The increased advanced cultural practices by using certified seed with improved varieties, optimum seed rate, sowing time, proper irrigation, fertilizers balance, and effectiveness proper row spacing's may be helpful to achieve seed yield and yield components (Nizamani *et al.*, 2014).

**Table 8:** *Seed yield (kg ha$^{-1}$) of lentil varieties as affected by different row spacing's.*

| Varieties | Row spacing's (cm) | | | Mean |
|---|---|---|---|---|
| | 15 | 30 | 45 | |
| M-85 | 1026.8 c | 1145.9 c | 1092.1 c | 1088.3 b |
| NIA-Masoor-2005 | 1256.6 bc | 1063.6 c | 1298.0 bc | 1206.1 b |
| NIA-Masoor-2016 | 1754.8 ab | 1863.6 a | 1679.9 ab | 1766.1 a |
| Mean | 1346.1 a | 1357.7 a | 1356.7 a | |
| Varieties SE (140.41) LSD (5%) (297.65), Row spacing's SE (140.41) LSD (5%) (297.65), V x RS SE (243.19) LSD (5%) (515.55) | | | | |

## Conclusions and Recommendations

It is concluded that variety NIA, Masoor-2016 and NIA, Masoor-2005 both varieties shows high yield potential under the row spacing's of 30 cm, it was proved the best performance as compared to other varieties under 30 cm row.

## Acknowledgement

The writing of research article supported/partially

and supported to conduct the experiment in this institute and help the write up. We are thankful to our colleagues who provided expertise greatly.

## Novelty Statement

The current study conducted to determine the optimal lines spacing for enhancing the production in Pakistan. The recommended line spacing was 30cm to harvest maximum lentil yield the province of Sindh.

## Author's Contribution

MMF conducted the study. MAS and NSS conceived the idea, and supervised the experiment. SR and MTK improved the manuscript through revisions and provide technical inputs. FDS helped in collecting the agronomic data of the crop. GSN provided technical inputs, proofread the work. MMA conducted statistical analysis of the data & supervised the manuscript writing process.

*Conflict of interest*

The authors have declared no conflict of interest.

## References

Akter, M.S.T. and Fahmida. 2016. Effect of planting geometry for yield and yield components of lentil. Department of Agronomy, Sher-e-Bangla Agricultural University Dhaka, thesis, pp. 1.

Analytical Software, 2005. Statistix 8.1 User's Manual, Tallahassee, FL.

Ayub, K., M. Rahim and A. Khan. 2001. Performance of exotic lentil varieties under rain-fed conditions in Mingora (NWFP) Pakistan. J. Bio. Sci., 1: 343-344. https://doi.org/10.3923/jbs.2001.343.344

Chen, C., P. Miller, F. Muehlbauer, K. Neill, D. Wichman and K. McPhee. 2006. Winter pea and lentil response to seeding date and micro and macro environments. Agron. J., 98: 1655-1663. https://doi.org/10.2134/agronj2006.0085

Cutworth, H.W., McB.G. Conkey, D. Ulrich, P.R. Miller and S.V. Angadi. 2002. Yield and water use efficiency of pulses seeded directly into standing stubble in the semi arid Canadian prairie. Can. J. Plant Sci., 82: 681-686. https://doi.org/10.4141/P01-111

FAO, 2019. Effect of row to row and plant to plant spacing on the growth and yield of lentil. http://agris.fao.org/aos/records.

Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedure for Agricultural Research, (2eds), Wiley, New York, USA. pp. 680.

Habbasha, K.M., S.M. Adam and F.A. Rizk. 1996. Growth and yield of pea (*Pisum sativum*) plant affected by plant density and foliar potassium application. Egypt. J. Hortic., 123(1): 33-51.

Habibzadeh, Y., R. Mameghani, A. Kasani and M. Mesgharbashi. 2006. Effect of density on yield and some vegetative and reproductive characters of three mungbean genotypes in Ahwaz area. Iran J. Agric. Sci., 37: 277-335.

Haq, Zia-Ul, M., S. Ahmad, M. Aslam Shad, S. Iqbal, M. Qayum, A. Ahmad, D.L. Luthria and R. Amarowicz. 2011. Compositional studies of lentil (*Lens culinaris* Medik.) cultivars commonly grown in Pakistan. Pak. J. Bot., 43(3): 1563-1567.

Hussain, N., A. Yasmeen, M. Arif and H. Nawaz. 2014. Exploring the role row spacing in yield improvement of wheat cultivars. Pak. J. Agric. Sci., 51(1): 25-31.

Jamali-Al, A.F., M.A. Turk and A.M. Tawaha. 2002. Effect of Ethephon spraying at three developmental stages of barley planted in arid and semi-arid mediterranean locations. J. Agron. Crop Sci., 188: 254-259. https://doi.org/10.1046/j.1439-037X.2002.00568.x

Kalita, H., P.C. Bora and M.C. Debnath. 2005. Effect of sowing date and tillage on soil properties, nutrient uptake and yield of linseed (*Linum usitatissimum* L.) grown in winter rice (*Oryza sativa* L.) fallows. Indian J. Agron., 50(1): 70-72.

Kazemeini, S.A., M. Edalat and A. Shekoofa. 2015. Interaction effects of deficit irrigation and row spacing on sunflower (*Helianthus annuus* L.) growth, seed yield and oil yield. African J. Agric. Res., 4(11): 1165-1170.

Khan, R.U., A. Ahad, A. Rashid and A. Khan. 2001. Chickpea production as influenced by row spacing under rain-fed conditions of Dera Ismail Khan. J. Biol. Sci., 1(3): 103-104. https://doi.org/10.3923/jbs.2001.103.104

Liliane, N.T and C.S. Mutengwa. 2020. Estimation of maize (*Zea mays* L.) yield per harvest area: Appropriate methods. Agronomy, 10(29): 2-18. https://doi.org/10.3390/agronomy10010029

Nizamani, G.S., I.A. Khan, A. Khatri, M.A.

Siddiqui, M.R. Nizamani and M.I. Khaskheli. 2014. Influence of different row spacing on agronomic traits in different wheat varieties. Int. J. Dev. Res., 4(11): 2207-2211.

Nourin, A., A. Kiran, S. Kaukab, A.U. Rehman, M.S. Saeed, A. Tahir, G. Riasat and E. Khan. 2019. Evaluation of lentil gene pool for yield and some yield related attributes. Universal J. Agric. Res., 7(1): 32-62. https://doi.org/10.13189/ujar.2019.070105

Ouji, A., S. El-Bok, N.O.B. Youssef, M. Rouaissi, M. Mouelhi, M. Ben Younes and M. Kharrat. 2016. Impact of row spacing and seeding rate on yield components of lentil (*Lens culinaris* L.). J. New Sci., 25(2): 1138-1144.

Panwar, K.S., A.S. Faroda, D.S. Malik, L.P.S. Ahhawat, K.K. Dhingra, M.R. Rao, R. C. Singh, D.R. Dahiya, Singh, Atar and R.P. Roy Sharma. 1980. Silver Jubilee Soc. Agron., pp. 1955-1980.

Parveen, K., and M.S.U. Bhuiya. 2010. Effect of method of sowing and seed rate on the yield and yield components of lentil. J. Agrofor. Environ., 4(1): 155-157.

Saxena, M.C., 2009. Plant morphology, anatomy and growth habit. In: W. Erskine, F. Maeuhlbauer, A. Sarker and B. Sharma (eds.). The Lentil: Botany, Production and Uses. 1st ed. CABI Publishing, London, UK. pp. 34-46. https://doi.org/10.1079/9781845934873.0034

Seyyed, G.M., J.S. Mohamad and R.D. Mohamad. 2014. Effect of sowing date and plant density on yield and yield components of lentil (*Lens culinaris* cv. Sistan). Annu. Res. Rev. Biol., 4(1): 296-305. https://doi.org/10.9734/ARRB/2014/4390

Singh, B.B., G.A. Ambawatia and M.S.S. Maharaj. 1994. Stress studies in lentil (*Lens esculanta* Moench). IV. Effect of removal of water stress on recovery of germination percentage in lentil. Legume Res., 17: 8-12.

Singh, H., S. Elamathi and P. Anandhi. 2009. Effect of row spacing and dates of sowing on growth and yield of lentil (*Lens culinaris*) under north eastern region of U.P. Legume Res., 32(4): 307-308.

Singh, O.N., M. Sharma and R. Dash. 2003. Effect of seed rate, phosphorus and FYM application on growth and yield of bold seeded lentil. Indian J. Pulses Res., 16(2): 116-128.

Stoilova, T. and M.G. Pereira. 1999. Morphological characterization of 120 lentils (*Lens culinaris* Medik) accession. Lens Newsl., 26(1-2): 7-10.

Wells, R., 1993. Dynamics of soyabean growth in variable planting patterns. Agron. J., 85: 44-48. https://doi.org/10.2134/agronj1993.00021962008500010009x