J Agric. Res., 2024, Vol.62(2)
www.jar.com.pk
Agriculture Department
Government of Punjab

ISSN: 2076-7897 (Online) / ISSN: 0368-1157 (Print)
DOI: https://doi.org/

Crossref

AGRONOMY

STANDARDIZATION OF PLANTING TIME AND SEED RATE OF KALONJI (*NIGELLA SATIVA* L.) IN SOUTH PUNJAB PAKISTAN

Asmat Ullah*[1], Saba Iqbal*[2], Muhammad Luqman[3], Arbab Jahangeer[4], Naveed Akhtar[5] and Muhammad Saqib[6]

[1] Principal Scientist, [2,4] Scientific Officer, Agronomic Research Station Khanewal, [3] Senior Scientist, Government Seed Farm Dhakkar, Pakpattan, [5] Chief Scientist,[6] Scientific Officer, Agronomic Research Institute, Faisalabad, Pakistan

*Corresponding author's email: sabaiqbal87@gmail.com,/ asmat.ullah@aari.punjab.gov.pk

Article received on: 02/05/2023
Accepted for publication: 28/12/2023

ABSTRACT

Introducing high value crop with standardized production technology among farmers in existing cropping system and in context of changing climate is a challenge. However, the significance of crop with economical production package attracts farming community to adapt new crop in production systems. There are many production options to economize production technology of crops. Among all, planting time of a crop is an important agronomic factor that significantly determines crop acclimatization and affects plant growth, development and seed production. Similarly, proper seed rate depicts plant population with a vital role to get good economic yield in a field. Therefore, in this study, the effects of various planting times and seed rates on the yield of *Nigella sativa* were investigated through field experimentation at the research area of the Agronomic Research Station, Khanewal, South Punjab, Pakistan for three consecutive winter seasons (2019-2022). The experiment was consisted of two components: planting time (October 15, November 1 and 15) and seed rate (6, 7 and 8 Kg ha^{-1}). The results of this study revealed that planting of *Nigella sativa* crop on November 1st gave higher number of branches per plant (4.22), seed per capsule (88.94), 1000-seed weight (5.42 g) and grain yield (691.38 Kg ha^{-1}) in all three consecutive winter seasons. Likewise, among seed rates, sowing of *Nigella sativa* using seed rate of 7 Kg ha^{-1} resulted in higher 1000-seed weight (4.83 g). However the interaction of both in treatment where *Nigella sativa* seed were sown on November 1st with seed rate 7 Kg ha^{-1} resulted in higher number of capsules per branch (11.16) and seed yield (742.93). Therefore, it is concluded and recommended that *Nigella sativa* crop should be planted on 1st November with seed rate of 7 Kg ha^{-1} to obtain higher economic yield. Being high value crop, it can be easily adjusted in existing cropping system of south Punjab region.

KEYWORDS: Medicinal; optimizing production; technology development, high value crop

INTRODUCTION

Herbs have been used as source of medicine in all cultures since ancient times (Malik et al., 2015). Diverse climatic conditions and distinctive phytogeography makes Pakistan rich in cultivation of aromatic and medicinal plants. In Pakistan, there are about 400–600 medicinal plant species out of 5700. Traditional medicines had been used by approximately 84% of the population for their basic health needs in the early 1950s (Alamgeer et al., 2018) but today, due to urbanization and modernity, this practice is restricted to inaccessible zones (Mussarat et al., 2014). However, the desire to use medicinal plants for various health conditions is increasing every day, so the concern about medicinal plants and their production process is increasing (Safaei, et al., 2017). Therefore, N. sativa is broadly used in several ways in Pakistan; nonetheless its cultivation on a commercial scale has been reported in the country (Ahmad et al., 2013). As the demand for medicinal plants in various medical treatments is increasing day by day, hence it is emerging as a potential crop and diversified crop especially on small-scale landholdings by reducing the risk of crop failure, improving crop yield and income generation (Rabbani et al., 2011) in the context of changing climate. However, introducing production techniques must be standardized for better and economical yield. A number of factors affect the growth and yield per unit area of N. Sativa, the most important of which are the sowing date (Waliullah et al., 2021) and the seed rate (Shesuleiman et al., 2021). Various seed rates influence the yield and related components significantly i.e. plant population per hectare, branches per plant, capsules per plant, seed per capsule, 1000 seed weight and ultimately crop yield (Shesuleiman et al., 2021). Optimal seed rates are critical for maximum seed yield as high planting densities negatively affect yield and yield components (Shesuleiman et al., 2021). Determination of accurate time of planting performs fundamental role ensuring that the plant's growth stage meets the desired environmental conditions which produce higher yields. Choosing the right planting time is the most important factor, as the growing season makes the most of natural resources available to crop. Kalonji germinates appropriately at the optimum temperature range of 6.19˚C~22.14˚C (Waliullah et al., 2021). In the late cultivation of kalonji, plant germination was reported weak in the spring due to low soil temperature and frost. However, plant growth is adversely affected by the shortened growing duration of plants and likelihood of concurrence of flowering time due to higher temperature because of delay in cultivation/ late planting. Therefore, in current study the planting times as well as seed rate of kalonji were optimized, moreover the effect of these factors on yield and yield components was also investigated for economic cultivation of kalonji in an arid climate.

MATERIALS AND METHODS

Experimental sites: The trial was conducted at the research area of the Agronomic Research Station, Khanewal (latitude; 30º18' 35.95'' N, longitude; 71º59' 40.14'' E; 454 m), South Punjab Pakistan (Figure 1) for three consecutive winter seasons (2019-2022). The physicochemical characters of the soil at the study area were analyzed prior to sowing. The experimental soil was sandy loam with a pH of 8.6, EC 4 dS cm-1, N content 0.06%, P content 6.9 ppm and K content 206.7 ppm.

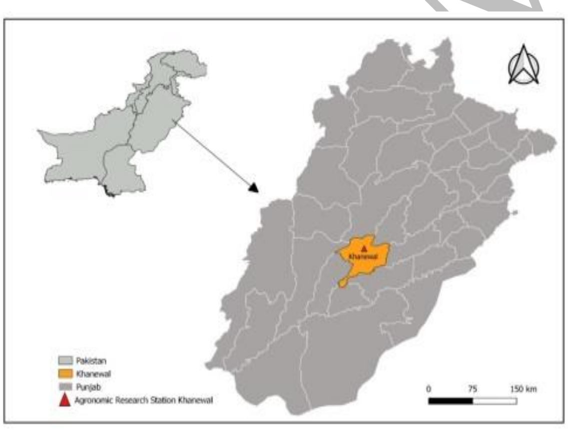

Figure 1: Geo-graphic location of experimental site

Experimental treatments: The experiment consisted of two factors: planting time (October 15, November 1 and November 15) and seed rate (6, 7 and 8 kgha-1). Treatments were implemented according to split plot design; planting times in the main plots and seed rates were placed in the subplots. The experiment was replicated thrice with net plot size of 5 m × 3 m.

Crop husbandry: Kalonji (Nigella sativa) was sown on the top of the beds keeping the R×R distance of 45 cm. Bed planter was used for sowing of crop by shaping the beds and planting kalonji in one pass. Fertilizers were applied at planting @ 55-25 NP kg ha-1. Nitrogen (N) was applied as Urea and phosphorous (P) was applied as diammonium phosphate (DAP). Crop was irrigated 5 times during growing period. Weeds (Phalaris minor, Chenopodium album, Avena fatua, Chenopodium murale etc.) were manually controlled through hoeing.

Weather: During all seasons of crop, 2019-20 was observed as cool as compared with 2020-21 and 2021-22 due to high rain fall (117.00 mm). Minimum temperature was recorded 7.65◦C during the month of January 2020 while maximum temperature 35.00◦C was recorded during the month of April 2020 (Figure 2).recorded 7.65◦C during the month of January 2020 while maximum temperature 35.00◦C was recorded during the month of April 2020 (Figure 2, 3, 4).

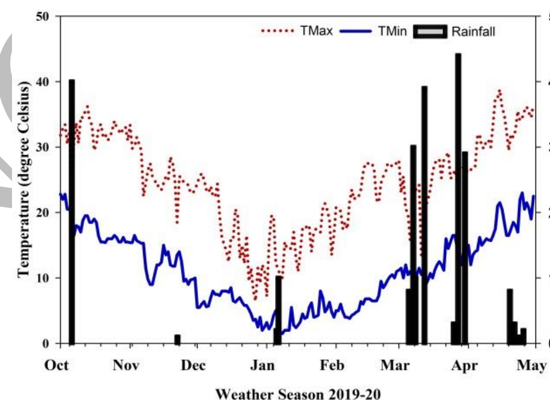

Figure 2: Weather data of crop season 2019-20

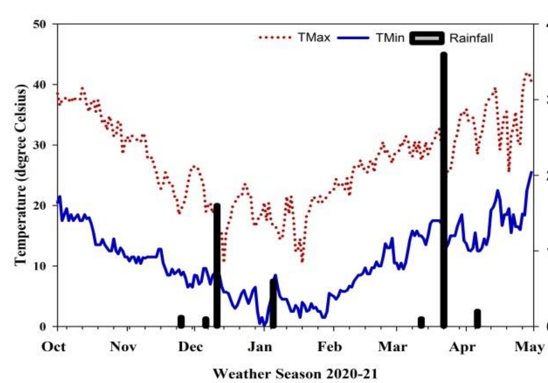

Figure 3: Weather data of crop season 2020-21

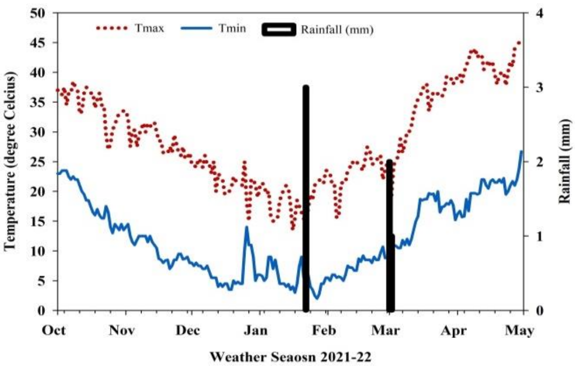

Figure 4: Weather data of crop season 2021-22

Observations**:** The data were recorded on the number of plants (m^{-2}), plant height (cm), branches per plant, capsules per branch, seeds per capsule, weight of 1000 seeds (g) and seed yield (kg ha^{-1}). Quadrates were placed in three different locations in each treatment plot to record the number of plants per m^{-2} and the obtained number were then averaged to note final plant population (m^{-2}) . For plant height, 10 plants from each treatment plot were randomly selected, tagged and their heights (cm) were measured using meter rod and then averaged to note final plant height. Same tagged plants were used to record number of branches per plant and number of capsules per plant and then averaged to record number of branches per plant and number of capsules per plant respectively. Seeds from 20 capsules were counted after being manually threshed and then mean value was calculated to get the number of seeds per capsule. A sub sample of 1000 seed from each treatment was counted, separated and weighted to note 1000-seed weight of each treatment. Fields were manually harvested, sun-dried for 5 days, manually threshed and cleaned, and weighed in Kg using a weighing scale, later converted to Kg ha^{-1} to record seed yield.

Statistical analysis**:** Fisher's analysis of variance technique was used to analyze the data via the statistical software STATISTIX 8.1. Least significant difference (LSD) tests were used at the 5% probability level to compare means.

RESULTS

During all study periods, higher plant population (m^{-2}) was recorded when crop was sown on November 1, whereas a higher number of plants per m^{-2} was recorded with a seeding rate of 8 Kg ha^{-1} (Table 1). Plant height was not significant in 2019–20, but higher plant heights were recorded when crop were sown on November 1 during the other study period (Table 1). Additionally, seeding rate was not significant for plant height during 2019–20 and 2021–22, but higher plant heights were recorded with a seed rate of 6 Kg ha^{-1} during 2020–21 (Table 1). In the case of seed rate, the number of branches per plant was not significant in 2019-20 and 2021-22, whereas in 2020-21, higher numbers were recorded on October 15 and November 1, the sowing dates of kalonji (Table 1). For seed rate, the number of branches per plant was not significant during 2019–20. However, higher branches per plant were recorded in 2020-21 and 2021-22 when using a seed rate of 6 kg ha^{-1} (Table 1).

Similarly, while the number of capsules per branch on the sowing date in 2019-20 was not significant, the number of capsules per branch was higher on November 1, the sowing date of kalonji, in 2020-21 and 2021-22. The number of capsules per branch was insignificant during 2019-20 and 2020-21, while a higher number of capsules per branch were recorded in 2021-22 when using a seed rate of 6 Kg ha^{-1} (Table 1). During 2019–20 and 2020–21, the interaction of seeding date and seeding rate was not significant for the number of capsules per branch, whereas in 2021–22, the higher number of capsules per branch was recorded when crop was sown November 1 using seed rate 6 Kg ha^{-1} (Table 1). Higher seed number per capsule was noted when crop was sown on November 1st (Table 2). Likewise, the 1000-grain weight was high when kalonji was sowed on November 1, and in the case of the seeding rate, the 1000-grain weight was not significant in 2020-21 and 2021-22, but the 1000-grain weight was high in 2019-20 when 7 kg ha^{-1} seed rate was used (Table 2). Sowing date was not significant for grain yield during 2020–21, whereas higher grain yields were recorded in 2019–20 and 2021–22 when crop were sown on November 1st. Seed rate was not significant for grain yield during 2019-20 and 2020-21, whereas higher grain yields were recorded in 2021-22 when a seed rate of 7 kg ha^{-1} was used (Table 2). In 2019–20, the interaction of sowing date and seeding rate was not significant, whereas in 2020–21 and 2021–22, higher grain yields were observed when crop was sown at a seeding rate of 7 Kg ha^{-1} on November 1 (Table 2).

DISCUSSION

This study revealed that late planting caused in decrease of grain yield in *Nigella sativa* and likewise while increasing seed rate above 7 Kg ha^{-1}. Kalonji sowing on November 1st significantly resulted in increase the number of plants m^{-2}, plant height, branches per plant, number of capsules per branch, number of seeds per capsule, 1000-seed weight and grain yield. Early and late plantings had fewer plants per m^2 due to temperature fluctuations. As planting was delayed, the temperature dropped and could not meet the temperature required for germination (Tahir *et al.,* 2009). Optimal seeding rate is an important factor regulating a crop's ability to capture available resources (Lloveras *et al.,* 2004). In addition, while higher seeding rates record higher plant populations. Seeding rates determine planting density, which affects crop growth, nutrient uptake, tillering capacity, grain number and weight, and ultimately yield due to competition between plants (Zohaib *et al.,* 2018). Also, sowing date is the most important factor in determining the desired plant height. Higher plant heights were recorded when kalonji was sown on November 1, which may be due to the appropriate conditions at this time of planting that ultimately improved plant growth (Waliullah *et al.,* 2021). In addition, the height reduction associated with late sowing may be due to the shorter growing season, as early-sown plants produced the tallest plants due to better environmental conditions, especially temperature and radiation (Tahir *et al.,* 2009). Seeding rate has a direct effect on plant height, as higher seeding rates in this study lead to higher plant height and vice versa. The results indicate that seeding rate, in addition to genetic composition, controls the growth behavior of *Nigella sativa* plants. The reason plants grow taller when you increase the seeding rate may be because plants compete for light (Gondal *et al.,* 2017).Higher number of capsules per plants of crop sown on November 1^{st} might be due to the planting of seed at right time which ultimately enabled crop to grow under better environmental condition and acquire better growth and photosynthetic production and ultimately longer duration for translocation of photosynthates from source to sink (Waliullah *et al.,* 2021).

The low number of capsules per branch during late sowing is because the growth period is short and the production of photosynthates is low (Tahir *et al.,* 2009). Number of capsules per branch was increased when kalonji was sown using seed rate 6 kg ha^{-1} whereas increasing seed rate resulted in lesser number of capsules per branch which might be due to higher plant population which ultimately resulted in higher completion for available resources between plants (Iqbal *et al.,* 2020). Planting time also affected the seed size/weight therefore plants sown on November 1^{st} produced heavier seed as compared to late sown crop which might be due to the acquisition of long and favorable growing period available to plants which grown on November 1^{st} whereas lighter grains in late sown crop might be the result of short growing season which resulted in rapid growth and lesser duration for grain filling. The 1000-seed weight due to seeding delay is likely due to reduced transport of photosynthetic products to mature seed (Mehmood *et al.,* 2018). Higher seeding rates also resulted in reduced seed weight per 1000 seeds, as at higher seeding levels, competition between plants generally increased, resulting in reduced seed size. Mid-seeding crops had higher grain yields while early and late planting resulted in reduced grain yields due to lower temperatures and unfavorable growing conditions of late sowing. The results obtained in this study show that plant growth is reduced when sowing are delayed, which reduces the number of capsules per plant and seed yield (Kg ha^{-1}). However, the higher yield contributors' traits of crops sown on November 1^{st} using a seed rate of 7 Kg ha^{-1} resulted in higher seed yields in the above treatment. As the final yield highly depends on yield contributing traits such as number of seed per capsule, 1000-seed weight and these all were amended when crop was sown on November 1^{st} with seed rate 7 Kg ha^{-1}.

CONCLUSION

This study demonstrated a sustained increase in plant population, plant height, branches per plant, capsules per branch, seeds per capsule, weight of 1000 seeds, and seed yield of *N. sativa* in arid conditions when sown on November 1^{st} at a seed rate of 7 kg ha^{-1}.

The above attributes were significantly lower in crops sown on October 15 and November 15 and at seeding rates of 6 and 8 Kg ha^{-1}. Hence in conclusion the optimal planting time for *N. sativa* under arid to semiarid conditions is November 1^{st} with optimal seeding rate of 7 Kg ha^{-1}. This crop is highly recommended for sowing in the region as high value crop. There is also dire need to develop marketing mechanism of kalonji.

REFERENCES

Ahmad, A., A. Husain, M. Mujeeb, S.A. Khan, A.K. Najmi, N.A. Siddique, Z.A. Damanhouri and F. Anwar 2013. A review on therapeutic potential of *Nigella sativa*: A miracle herb. Asian Pac. J. Trop. Biomed. 3:337-352.

Alamgeer, S.A., H. Asif, W. Younis, H. Riaz, I.A. Bukhari and A.M. Assiri. 2018. Indigenous medicinal plants of Pakistan used to treat skin diseases: a review. Chin. Med. 19:13-52.

El-Mekawy, M.A.M. 2012. Influence of planting date on growth and yield of *Nigella sativa* L. J. Agric. Environ. Sci. 12:499-505.

Gondal, M.R., A. Hussain, S. Yasin, M. Musa and H.S. Rehman. 2017. Effect of seed rate and row spacing on grain yield of sorghum. SAARC J. Agric. 15:81-91.

Iqbal, J., A. Zohaib, M. Hussain, A. Bashir, M. Hamza, W. Muzaffer, M.T. Latif and N. Faisal. 2020. Effect of seed rate on yield components and grain yield of ridge sown wheat varieties. Pak. J. Agri. Res. 33:508-515.

Lloveras, J., J. Manent, J. Viudas, A. López and P. Santiveri. 2004. Seeding rate influence on yield

and yield components of irrigated winter wheat in a Mediterranean climate. Agron. J. 96:258-265.
Malik, Z.A., A. Jahangeer, R. Ballabha, R.W. Bussmann and A.B. Bhatt. 2015. Ethnomedicinal plants traditionally used in health care practices by inhabitants of Western Himalaya. J. Ethnopharmacology 172:133-144.
Mehmood, A., K.K. Naveed, A. Azeem, N. Khan, Ali and S.M. Khan. 2018. Sowing time and nitrogen application methods impact on production traits of Kalonji (*Nigella sativa* L.). Pure Appl. Biol. 7:476-485.
Mussarat, S., N.M. Abdel-Salam, A. Tariq, S.M. Wazir, R. Ullah and M. Adnan. 2014. Use of ethnomedicinal plants by the people living around indus river. Evid. Based Complement Alternat. Med. 2014:1-14.
Rabbani, M.A., A. Ghafoor and M.S. Masood. 2011. Narc-kalonji: an early maturing and high yielding variety of *Nigella sativa* released for cultivation in Pakistan. Pak. J. Bot. 43:191-195.
Safaei, Z.A., G. Azizi, Davarynejad and H. Aroiee. 2017. The effect of planting seasons on quantitative and qualitative characteristics of Black cumin (*Nigella sativa* L.). J. Med. Plants By-products 1:27-33.
Shesuleiman, M., H. Mengistu and A. Jaleta. 2021. Black cumin (*Nigella sativa* L.) at Burusa, Southwestern Ethiopia. Amer. J. Plant Biol. 6:78-83.
Tahir, M., A. Ali, M.A. Nadeem, A. Hussain and F. Khalid. 2009. Effect of different sowing dates on growth and yield of wheat (*Triticum aestivum* L.) varieties in district Jhang, Pakistan. Pak. J. Life Soc. Sci. 7:66-69.
Waliullah, M.D., M. Hossain and H. Rehman. 2021. Influence of sowing dates and sowing methods on growth and seed yield of black cumin (*Nigella sativa* L.). J. Tropical Crop Sci. 8:24-33.
Zohaib, A., T. Tabassum, A. Jabbar, S.A. Anjum, T. Abbas, A. Mehmood, S. Irshad, M. Kashif, M. Nawaz, N. Farooq, I.R. Nasir, T. Rasool, M. Nadeem and R.

Table 1: Effect of planting time and seed rate on number of plants (m^{-2}), plant height (cm), branches per plant and capsules per branch of *Nigella sativa*

Treatments	Number of plants (m^{-2})				Plant height (cm)				Branches per plant				Capsules per Branch			
	2019-20	2020-21	2021-22	Mean	2019-20	2020-21	2021-22	Mean	2019-20	2020-21	2021-22	Mean	2019-20	2020-21	2021-22	Mean
Sowing dates (D)																
15th October (D_1)	11.11 B	13.33 B	17.33 B	13.92	40.96	42.44 B	73.22 B	52.21	2.80	3.11A	4.56	3.49	3.33	4.11B	18.33 B	8.59
1st November (D_2)	15.22 A	14.33 A	19.56 A	16.37	46.01	49.67 A	98.22 A	64.63	4.42	3.56A	4.67	4.22	3.29	6.33A	20.56 A	10.06
15th November (D_3)	9.89B	12.56 B	17.22 B	13.22	52.11	35.39 C	73.56 B	53.69	3.13	2.22B	4.67	3.34	3.93	3.33C	12.22 C	6.49
LSD p 0.05	1.623	0.854	0.78	-	ns	1.496	1.57	-	ns	0.854	ns	-	ns	0.734	0.59	-
Seed Rate (S)																
6 kg ha^{-1} (S_1)	10.00 C	11.44 C	16.00 C	12.48	44.31	40.50 C	78.67	54.49	2.76	3.67A	5.56A	4.00	3.33	4.67	19.22 A	9.07
7 kg ha^{-1} (S_2)	12.11 B	13.67 B	18.22 B	14.67	45.50	42.17 B	80.67	56.11	3.11	3.00B	4.78B	3.63	3.53	4.44	17.89 B	8.62
8 kg ha^{-1} (S_3)	14.11 A	15.11 A	19.89 A	16.37	49.27	44.83 A	80.67	58.26	4.49	2.22C	3.56C	3.42	3.69	4.67	14.00 C	7.45
LSD p 0.05	0.839	0.670	0.61	-	ns	0.916	ns	-	ns	0.541	ns	-	ns	ns	0.78	-
D×S																
D_1×S_1	9.00	11.00	15.33	11.78	50.40	43.83	72.00	55.41	2.73	4.00	5.33	4.02	4.13	4.67	21.00 b	9.93
D_1×S_2	11.33	13.67	17.33	14.11	37.87	42.00	72.33	50.73	2.73	3.00	5.00	3.58	3.20	4.00	18.00c	8.40
D_1×S_3	13.00	15.33	19.33	15.89	44.67	41.50	75.33	53.83	3.87	2.33	3.33	3.18	3.27	3.67	16.00 d	7.65
D_2×S_1	12.33	12.67	17.33	14.11	53.87	52.50	91.67	66.01	2.93	4.67	5.67	4.42	4.47	6.33	22.67 a	11.16
D_2×S_2	15.67	14.67	19.67	16.67	45.27	49.17	93.67	62.70	3.27	3.67	4.67	3.87	3.40	6.00	21.67 ab	10.36
D_2×S_3	17.67	15.67	21.67	18.34	48.67	47.33	94.33	63.44	7.27	2.33	3.67	4.42	3.20	6.67	17.33c	9.07
D_3×S_1	8.67	11.44	15.33	11.81	52.07	38.17	72.33	54.19	3.73	2.33	5.67	3.91	3.20	3.00	14.00 e	6.73
D_3×S_2	9.33	13.67	17.67	13.56	39.73	35.33	76.00	50.35	2.40	2.33	4.67	3.13	3.40	3.33	14.00 e	6.91
D_3×S_3	11.67	15.11	18.67	15.15	44.70	32.67	72.33	49.90	2.13	2.00	3.67	2.60	3.40	3.67	8.67s	5.25
LSD p 0.05	ns	ns	ns	-	ns	ns	ns	-	ns	Ns	ns	-	ns	ns	1.35	-

Means sharing same case letters do not differ significantly at p≤0.05

Table 2: Effect of planting time and seed rate on seed per capsule, 1000-seed weight (g) and seed yield (Kg ha^{-1}) of *Nigella sativa*

Treatments	Seed per capsule				1000- seed weight (g)				Seed yield (Kg ha^{-1})			
	2019-20	2020-21	2021-22	Mean	2019-20	2020-21	2021-22	Mean	2019-20	2020-21	2021-22	Mean
Sowing dates (D)												
15th October (D_1)	65.66 B	52.22B	72.78B	63.55	5.62 B	5.05B	2.63B	4.43	95.93 B	468.00	607.70B	390.54
1st November (D_2)	75.60 A	107.11A	84.11A	88.94	6.34 A	6.82A	3.09A	5.42	161.25 A	858.00	1054.90A	691.38
15th November (D_3)	55.22 C	51.33B	67.11C	57.89	5.57 B	5.07B	2.75B	4.46	83.53 B	453.44	370.60C	302.52
LSD p 0.05	ns	5.324	3.57	-	ns	0.199	0.20	-	ns	ns	68.43	-
Seed Rate (S)												
6 kg ha^{-1} (S_1)	65.34	72.44	74.22	70.67	5.71 B	5.62	2.76	4.70	108.98	553.78	655.00B	439.25
7 kg ha^{-1} (S_2)	64.84	69.56	74.11	69.50	5.93 A	5.69	2.86	4.83	116.64	662.44	744.89A	507.99
8 kg ha^{-1} (S_3)	66.29	68.67	75.67	70.21	5.89 A	5.63	2.86	4.79	115.09	563.22	633.22B	437.18
LSD p 0.05	ns	ns	ns	-	ns	Ns	ns	-	ns	ns	55.70	-
D×S												
D_1×S_1	54.60	56.00	75.33	61.98	5.84	5.02	2.53	4.46	103.63	406.00f	615.30c	374.98
D_1×S_2	66.80	50.67	70.33	62.60	5.48	5.10	2.70	4.43	93.85	516.33d	599.30c	403.16
D_1×S_3	73.13	50.00	72.67	65.27	6.49	5.02	2.67	4.73	152.42	481.67e	608.30c	414.13
D_2×S_1	55.53	107.00	82.00	81.51	5.36	6.80	2.97	5.04	62.44	828.33b	999.00b	629.92
D_2×S_2	66.47	107.00	86.33	86.60	5.77	6.85	3.17	5.26	102.49	949.00a	1177.30a	742.93
D_2×S_3	76.87	107.33	84.00	89.40	6.54	6.81	3.13	5.49	180.34	796.67c	899.30b	625.44
D_3×S_1	55.53	54.33	65.33	58.40	5.52	5.05	2.77	4.45	84.53	427.00f	350.70e	287.41
D_3×S_2	63.70	51.00	65.67	60.12	5.62	5.12	2.70	4.48	91.44	521.99d	458.00d	357.14
D_3×S_3	76.80	48.67	70.33	65.27	5.98	5.06	2.78	4.61	150.97	411.33f	303.00e	288.43
LSD p 0.05	ns	ns	ns	-	ns	Ns	ns	-	ns	28.270	96.48	-

Means sharing same case letters do not differ significantly at p≤0.05

CONTRIBUTION OF AUTHORS

Sr. No.	Author's name	Contribution	Signature
1.	Asmat Ullah	Conceived the idea and conducted the research. Design graphs and review first draft of paper	
2.	Saba Iqbal	Collected, analyzed, compiled data and first draft of paper	
3.	Muhammad Luqman	Assisted in collected of data	
4.	Arbab Jahangeer	Tabulation and interpretation of data	
5.	Naveed Akhtar	Proof reading and guidance	
6.	Muhammad Saqib	Tabulation of data	