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Ajmer Nigella -20: A new high-yielding nigella variety

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Abstract

Nigella (*Nigella sativa* L.) well known as black cumin belongs to the Ranunculaceae family and is an important seed spice crop grown in India. The genus *Nigella* comprises more than 116 species, the most popular of which is *Nigella sativa* L. Nigella is classified as a seed spice because its dried seeds are used as a spice. ICAR-NRCSS, Ajmer has developed the Ajmer Nigella- 20 (AN-20) variety through the mass selection breeding method. This variety starts flowering in 85-90 days after seed sowing in the field and matures in 145-150 days. It belongs to the medium maturity group. Plants of AN-20 are erect type, bear white flowers and their siliqua consist of 65-80 seeds per siliqua. Ajmer Nigella-20 seeds contain higher amount of total oil (28.08 %) than other released varieties. In the multi location trail, AN-20 resulted in 1025 kg per ha seed yield which was 43% higher than Azad Kalonji (714 kg ha^{-1}). Ajmer Nigella-20 is recommended for cultivation in all nigella growing areas of Rajasthan.

Key words: Nigella, yield, quality, total oil, variety

Introduction

Nigella (*Nigella sativum* L.) belonging to the family Ranunculaceae is an important minor seed spice crop grown in India. It is mainly cultivated in states, like Madhya Pradesh, Bihar, Punjab and Assam. Besides India, nigella is also cultivated in Pakistan, Sri Lanka, Bangladesh, Nepal, Egypt and Iraq. Nigella seeds have been used as an important ingredient of medicine since ancient times. Presently, it is cultivated in many subtropical regions of the world including Asia, the Middle East, and North Africa (Barut *et al*., 2023). The global demand for nigella seeds is driven by their use in culinary applications, traditional medicine, and natural remedies. The seeds are traded internationally, with major exporters including India and Turkey, while consumers worldwide appreciate their unique flavor and health benefits. Nigella seeds are known for their anti-inflammatory and antioxidant effects, which help reduce inflammation and combat oxidative stress. These seeds support immune function, aid digestion, and may improve respiratory health.

They also possess antimicrobial properties, assist in blood sugar regulation, and are used in skincare for conditions like eczema and acne. (Ramadan 2007). The most active constituent of nigella is thymoquinone, representing 18.4% to 24% of the volatile oil and thymol (Albakry *et al*., 2022). Many studies have highlighted the pharmacological effects of thymoquinone and thymol, showcasing their potential as crucial components in both indigenous medicine systems and the pharmaceutical industry. Thymoquinone, a major active compound in nigella seeds, is known for its anti-inflammatory, antioxidant, and anticancer properties. It plays a significant role in reducing inflammation, protecting cells from oxidative stress, and potentially inhibiting the growth of cancer cells (Ten Sande *et al*., 2017). The essential oil found in the seeds, which has a demand in the perfume and medicinal industries, ranges from 0.5 to 1.4% (Malhotra, 2004, Dubey *et al.,* 2016). Rajasthan is a state that cultivates a lot of seed spices. Recently the nigella crop is grown in several parts of Rajasthan and other states of India as an alternative seed spice crop that has high potential. The climate in south-eastern Rajasthan was found suitable for seed spices including nigella (Verma *et al*., 2019). The area under nigella in Rajasthan recorded 10157 hectares and 7677 hectares respectively with a maximum area of 7167 hectares in the Jhalawar district of the state and the total production of nigella in Rajasthan is 8522 mt with a maximum contribution of 5734 mt from Jhalawar district followed by Chittor (Verma *et al*., 2019). To meet the increasing demand, there is a need to develop high-quality and yielding genotypes or varieties by employing different crop improvement techniques. Improved varieties will be able to fulfil the continuous domestic as well as global demand for raw materials and their finished product.

All crop improvement programmes start with germplasm collection, evaluation and documentation activities and then further desirable genotype selection. Breeding objectives for nigella (*Nigella sativa*) focused on several key areas to enhance crop performance and value. One major goal is to improve seed yield, aiming for varieties that produce more seeds per plant. The varieties with better adaptability to various environmental conditions, such as different soil types and climates, to expand cultivation areas. Additionally, improving agronomic traits, like plant structure and uniformity, can make cultivation and harvesting more efficient. Keeping these objectives in consideration different germplasm of nigella was evaluated in station trial. New germplasm AN-20 resulted in, 43 per cent higher seed yield over the check variety namely Azad Kalonji in station trials, hence, further tested under multilocation trials of ATC, Kota during 2013-14.Ajmer Nigella-20 variety release proposal of Ajmer Nigella-20 was submitted to the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Horticultural crops for state release during, 2015. Ajmer Nigella-20 variety released by the Rajasthan State Seed Sub-Committee for Agriculture & Horticultural Crops in 2015. Seed of Ajmer Nigella-20 has been deposited in NBPGR and IC number *ie*., IC-612496 has been allotted for future reference for retrieval from long-term storage system of ICAR-NBPGR, New Delhi.

Materials and Methods

Evaluation of Ajmer Nigella-20

The present varietal evaluation experiment was carried out during 2010-2014 at the experimental fields at the National Research Centre on Seed Spices, Ajmer (26° 27′ 0′′ N, 74° 38′ -1′′ E and 700 m above sea level) and adaptive trail centre (ATC), Nanta, Kota (Zone 5). Soil of the experimental site at ICAR-NRCSS, Ajmer had sandy loam in texture and pH ranges near about neutral reaction pH 7.2. The maximum and minimum temperature during the growing season of nigella (October to April) recorded were5°C to 39°C. The seeds of Ajmer Nigella-20 were collected from the local market Ajmer in 2009 and evaluated under Randomized Block Design with three replications during rabi season at both the location with check varieties (Azad Kalonji and AN-1). In each replication, genotypes were sown in a plot of 10.0 m^2 accommodating 8 rows of 4 m length spaced 25 cm apart with an intra-row spacing of 10 cm. All the recommended package of practices was followed to raise a healthy crop. The observations were recorded for plant height, days to 50 % flowering, days to maturity, primary branches per plant, secondary branches per plant, and capsules per plant. Based on the average single plant seed yield (g) the per hectare seed yield (kg) was calculated. Test weight (1000-seed weight; 1000-seed were counted at random from the

harvest of each plot and weighted in grams to represent 1000-seed weight).The extraction of total oil from seeds of AN-20, Azad Kalonji and AN-1 varieties was performed using a Soxhlet apparatus. Analysis of variance was done by the method suggested by Panse and Sukhatme (1967). It was developed by multiplication of and subsequent screening of the population and bulk selection based on desirable attributes. Evaluation of selected population for seed yield and economic other traits during 2010-11. The selected promising genotype was evaluated in station trial as compared to check varieties during 20012-14 at ICAR-NRCSS, Ajmer and Kota.

Varietal description

The Nigella-20 variety features an erect plant structure and dense foliage, supporting its potential for high productivity. It bears white flowers and has leaves with sparse feathering, an oblong shape, and a length of 5.8 cm. The first internodes measure 1.7 cm. The plant is moderately branched, with 12 primary and 27 secondary branches per plant, and reaches a height of 65 cm. Each plant produces about 66 capsules, each with 7 horns, and contains 88 to 90 seeds per capsule. With a test weight of 3.2 grams and reaching 50% flowering in approximately 85 days, the Nigella-20 variety is well-suited for commercial cultivation.

Results and Discussion

Yield and yield attributing trait performance in multi-location

The data in Fig.1 showed the various yield and yield attributing characters of three nigella varieties: AN-20, Azad Kalonji (Check), and AN-1 (Check). The variety AN-20 exhibited superior performance in most yield-attributing traits compared to Azad Kalonji and AN-1.

Photo: Morphological features of Ajmer Nigella-20 a) Flower C) Plant d) seed

AN-20 has the tallest plant height at 65.73 cm, compared to 59.78 cm for Azad Kalonji and 63.49 cm for AN-1. It also has the highest number of primary and secondary branches per plant, with 11.92 primary branches and 58.40 secondary branches, surpassing Azad Kalonji's 9.96 primary and 51.11 secondary branches, and AN-1 10.11 primary and 50.13 secondary branches. Regarding days to flowering traits, AN-20 takes slightly longer to reach 50% flowering at 85.89 days, compared to 84.22 days for Azad Kalonji and 84.44 days for AN-1. However, AN-20 compensates with more siliqua per plant (58.23), compared to 51.95 for Azad Kalonji and 51.49 for AN-1. Furthermore, AN-20 produced the highest number of seeds per siliqua at 86.14, while Azad Kalonji had 75.00 and AN-1 had 72.79. The test weight, which indicates the weight of seeds, is also highest for AN-20 at 2.26 grams, compared to 1.71 grams for Azad Kalonji and 1.97 grams for AN-1. Importantly, AN-20 has a significantly higher total oil content at 28.00%, whereas Azad Kalonji has the lowest at 20.36% and AN-1 is at par with AN-20 at 27.73%. Overall, AN-20 demonstrates superior yield attributing traits, making it a highly productive variety with higher yield potential and greater oil content compared to Azad Kalonji and AN-1.

The data presented in Fig 2 showed the results of varietal evaluation trials conducted in 2010-2013-14 at two locations: ICAR-NRCSS in Ajmer and ATC, Nanta Farm in Kota. In 2010-11 at ICAR-NRCSS, Ajmer, AN-

20 yielded 1099.72 kg ha^{-1}, Azad Kalonji yielded 803.33 kg ha^{-1}, and AN-1 yielded 629.44 kg ha^{-1}. The following year, 2011-12, AN-20 yielded 1020.30 kg ha^{-1}, Azad Kalonji saw a significant drop to 363.33 kg ha^{-1}, and AN-1 increased to 788.89 kg ha^{-1}. In 2012-13, the yields for AN-20, Azad Kalonji, and AN-1 were 1003.55, 790.66, and 757.13 kg ha^{-1} respectively. The 2013-14 season at ICAR-NRCSS, Ajmer, showed a slight decline in yields with AN-20 at 1000.00 kg ha^{-1}, Azad Kalonji at 790.00 kg ha^{-1}, and AN-1 at 757.00 kg ha^{-1}. In 2013-14 at ATC, Nanta Farm, Kota, AN-20 yielded 1006.00 kg ha^{-1}, Azad Kalonji had its highest yield of 823.00 kg ha^{-1}, and AN-1 yielded 674.00 kg ha^{-1}. Across all years and locations, AN-20 consistently had the highest yields. Azad Kalonji showed variability, with a particularly low yield in 2011-12 but generally improved performance thereafter. AN-1 had moderate and relatively stable yields, usually higher than Azad Kalonji in most years but lower than AN-20. Overall, AN-20 appears to be the most productive variety which produced 43.67 % higher yield than the check variety Azad Kalonji and 42.23 % higher than the check variety AN-1. These results suggested that AN-20 is the most productive variety across different years and locations. Variations in yield between the locations indicate that environmental factors may also play a significant role in crop performance. The data provides a comparative analysis useful for selecting crop varieties based on their yield performance.

The box plot analysis of the varieties AN-20, Azad Kalonji (Check), and AN-1 (Check) for test weight revealed notable differences in their distributions (Fig3). AN-20 has the highest median value, approximately 2.26, indicating that its central tendency is higher compared to the other varieties. It also has a relatively narrow inter quartile range (IQR), suggesting low variability within its middle 50% of values. Azad Kalonji (Check) exhibited the lowest median value, around 1.71, with the smallest IQR, indicating the least variability and the most consistent data among the three variety. AN-1 (Check) has a median value of about 1.93, showing moderate variability with an IQR wider than Azad Kalonji (Check) but narrower than AN-20. The whiskers for AN-1 (Check) extended from approximately 1.92 to 2.06, reflecting a broader spread of data points. From the data it was opined that AN-20 consistently holds the highest values, Azad Kalonji (Check) demonstrates the lowest and most consistent values, while AN-1 (Check) falls between the other two in terms of both central tendency and variability. These insights provide a clear understanding of the relative distributions and characteristics of each variety.

The analysis of mean data of total oil content for AN-20, Azad Kalonji (Check), and AN-1 (Check) is presented in Fig 4. The average mean was 28.08 for AN-20, 20.36 for Azad Kalonji (Check), and 27.73 for AN-1 (Check). The standard error was also calculated to see how much the data varied. AN-20 had the most consistent data, with a narrow variation. Azad Kalonji (Check) showed more variation. AN-1 (Check) was fairly consistent, similar to AN-20. The differences in oil content data ranges and variations might be due to different genetic constitutions of varieties.

Usages and suitability for cultivation

Ajmer Nigella-20 variety is suitable for loamy and sandy loam soils having good drainage facility. Dry cool and frost-free environment particularly in January is most suitable. This variety is very much suitable for all nigella growing areas of Rajasthan and can meet growing market demands more effectively. This variety is suited to different climates or soil types, expanding the regions where nigella can be cultivated. The complete package of practices is given in Table 1. Nigella seeds are used in food as flavouring additive in the breads and pickles because it has very low level of toxicity (Goreja, 2003; Lal *et al*., 2018, Meena *et al*., 2010). Most of the therapeutic properties of this plant are due to the presence of thymoquinone.

Conclusion

The Ajmer Nigella-20 (AN-20) is the most productive variety across different years and locations. Yield performance of Nigella variety AN-20 was 1025.91 kg ha^{-1} (43.67 % higher than Azad Kalonji) and found superior than both the check varieties (Azad Kalonji and AN-1). Total oil content was almost 28.08 % greater in AN-20 in comparison to both the check varieties. Ajmer Nigella-20 is recommended for cultivation in all Nigella growing areas of Rajasthan.

Conflicts of Interest : The authors declare no conflicts of interest.

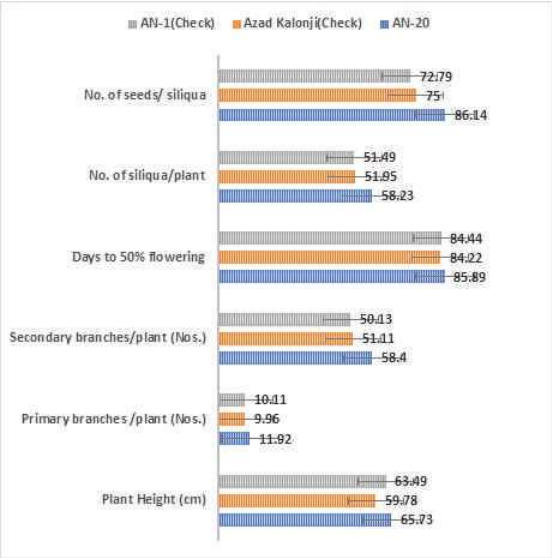

Fig 1: Ancillary data of nigella variety AN-20 tested at ICAR-NRCSS, Ajmer from 2010-11 to 2013-14

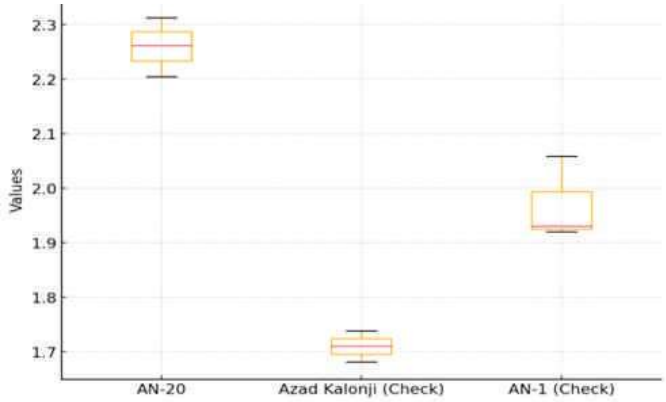

Fig3: Comparative test weight of AN-20 and check varieties tested at ICAR-NRCSS, Ajmer in during 2010-11 to 2013-14

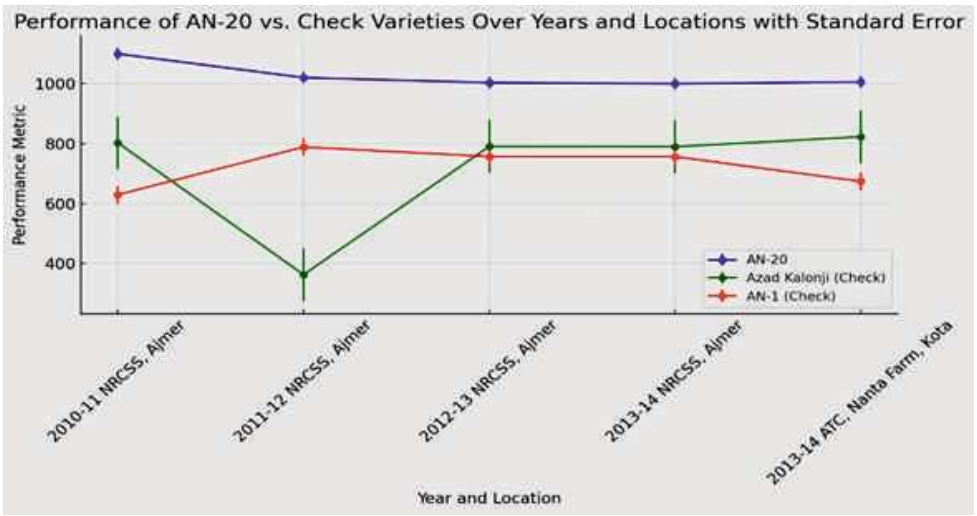

Fig. 2 Seed yield (kg ha^{-1}) of Nigella varieties in trials conducted at different locations across the Rajasthan state (Ajmer & Kota)

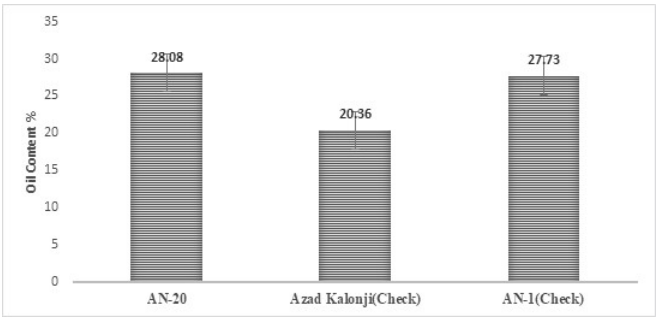

Fig 4: Total oil content of AN-20 and check varieties tested at ICAR-NRCSS, Ajmer during 2010-11 to 2013-14

S. No.	Activity	Details
A	**Climate and soil**	Ajmer Nigella-20 is recommended for cultivation in all nigella growing areas of Rajasthan. It is found suitable for cultivation on loamy and sandy loam soils having good drainage conditions, dry cool and frost-free environments. Soil pH range near about neutral reaction but can be grown well on soil pH 6 – 8. Fairly warm weather during sowing with a temperature of 20-25ºC is desirable.
B	**Preparation of land**	The field should be well prepared levelled and smooth for getting good germination, growth and yield. A total of 2 -3 ploughings are required, first ploughing should be done by soil turning plough followed by light ploughings by harrow or cultivator or desi plough. Fine tilth of field is required for easy penetration of plant roots in soils, for increasing water holding capacity of soil and better uptake of nutrients by the plants from soil strata.
B	**Sowing time**	15th to 30th October is most suitable for sowing.
C	**Sowing method & seed rate**	7-8 kg seed ha $^{-1}$ sufficient with 25 cm line to line and 10 cm plant to plant distance was found best for maximizing the seed yield.
D	**Seed treatment**	The seeds should be treated with bavistin or thiram @ 2.0 g kg^{-1} or Trichoderma @10g kg^{-1} seed before sowing.
E	**Fertilizer and manures**	In general, the well ro tten farm yard manure of 5 -10 t ha^{-1} is added while preparing the field. NPK: 50:40:20 kg ha^{-1}. Total quantity of phosphorus, potash and 1/3 dose of nitrogen should be applied as basal dose while rest of the nitrogen in two equal splits, first at 30 days after sowing, while rest at flowering time as top dressing in standing crop.
F	**Irrigation**	5-6 irrigations are sufficient depending on soil type and climatic condition. Most critical stages for irrigation are flowering and seed formation. Therefore, crop should not be allowed to face water stress at flowering and seed formation stages.
G	**Intercultural operations**	Initial growth of nigella crop is very slow; therefore, it is necessary to keep the field free from weeds. A total of 2 -3 manual weddings and hueing's are required, the first weeding should be done after 30 days of sowing accompanied by thinning from rows after maintaining suggested intra row spacing. Weeds can also be controlled by a pre - emergence application of Oxadiargyl @ 0.075 kg ha^{-1} + one hand weeding at 45 DAS is good techniques for weed control in nigella. Care must be taken that there is sufficient moisture in the soil at the time of application of weedicides for enhancing effectiveness of weedicides.
H	**Disease and pest control measures**	**Disease** ***Root rot*:** AN-1 is tolerant to root rot with PDI 4.4 in field condition. **Control:** The seeds treatment with Trichoderma, 6 -8g/kg seed or carbendazim @ 1g/kg proves effective in control of disease. **Insects:** ***Aphid:*** These are major yield reducing factor of nigella crops in all the growing areas. Aphids suck the sap from the young growing twigs, flower buds and fruits and devitalize the plants. Timely management of aphids is necessary to prevent the crop from economic losses. **Management** • At early colonization of aphids, spraying of botanical insecticides like Neem Seed Kernal Extract (NSKE) at (5%) concentration, Neem oil (2%) give good control and prevent the buildup of large colony on the plants for some time. • In case of higher population development spraying of Imidacloprid (0.005%) gives effective control. If required, spray may be repeated after 15 to 20 days for effective control of aphid. ***Cutworm*** Cut worm infestation is found serious in some areas. The larvae remain inside the soil near the base of the plant. At night the larvae feed voraciously on the leaves and tender stems and branches of the nigella plants, caused severe damage to the crop in initial growth stage. **Management** ▪ To control this insect regular field inspection should be made to detect the appearance of the pest if infestation is more than economic threshold level, application of Carbofuran or Prorate 10 G @ 10 kg ha^{-1} just before sowing in the soil near the base of the plants is useful to bring this pest under control. ▪ Summer ploughing, cleaning of fields and burning of debris should be followed by the grower.

Termites

Termites live in the soil strata and feed on the plant roots and other debris. This insect damage Nigella crop generally at full vegetative growth stage.

Management

- Application of Phorate 10g @ 10 kg ha^{-1} just before sowing of seeds in the soil near the base of the plant can be useful to bring this pest under control.
- Lighter but regular irrigation is recommended to minimize the termite attack as availability of appropriate moisture in the root zone repels the termite.

I Harvesting The crop matures in 140 -150 days after sowing. It should be harvested when the seed attained full maturity in capsule and have turned to full brown/ light black colour. Average seed yield varies from 900-1000 kg ha^{-1}. The seeds thereafter are winnowed and dried, up to 8-9% moisture in produce.

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