



SHORT COMMUNICATION

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## VRCAR-252 (INGR22088): Anthocyanin-rich petaloid-CMS line of black carrot with better heterotic potential

BK Singh\* and Pradip Karmakar

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ICAR-Indian Institute of Vegetable Research (IIVR), Jakhini, Varanasi, Uttar Pradesh, India.

\*Corresponding author; Email: bksinghkushinagar@yahoo.co.in

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The storage root of cultivated carrot (*Daucus carota* subsp. *sativus*) is one of the richest sources of various pigments and has commercial significance globally. It is broadly categorized into two segments, i.e., anthocyanin/purple group (Black and Rainbow carrot) and carotenoid group (Orange, Red and Yellow carrot) on the basis of the presence of root pigments. Black carrot root is comprised with dark purple (solid purple) pigmentation of both root exterior (epidermal layer) and root interior [cortex (outer-phloem), phloem and xylem (core)]; and is one of the greatest sources of anthocyanins possessing very high antioxidative ability. Black carrot, "a potential pigment crop," is very much suitable for healthy salad; preparations of sweets, fresh & fermented juice, and purple tea; and pharmaceutical & nutraceutical uses as protective food supplements, healthy food colorants, and cosmetics. The roots of black carrot are an excellent source of plant-derived anthocyanins (211 mg/100 g FW), phenolics (268 mg GAE/100 g FW) and flavonoids (119 mg CE/100 g FW); having better anthocyanin yield potential (52 kg/ha); and greater antioxidative capacity (FRAP value of 44  $\mu$ mol TE/g FW) (Singh *et al.* 2018, Singh *et al.* 2021, Singh *et al.* 2022). The male sterility in carrots was discovered and analyzed by Thompson (1962) and Hanschke & Gabelman (1963); and in India, Kalia *et al.* (2019) have transferred CMS system in red, orange and purple-colored Asiatic carrots. Considering the health and nutritional benefits, multifarious uses and industrial importance of plant-derived natural anthocyanins of black carrot, and the role of cytoplasmic male sterility (CMS) in the development & cost-effective seed-multiplication of  $F_1$  hybrids, the CMS system- a trait of commercial importance was transferred in the various colored carrots through backcross breeding at ICAR-IIVR, Varanasi, UP (Singh and Karmakar 2021). The petaloid-CMS line was developed by crossing the naturally occurring CMS plant in an open-pollinated population with an orangish-

red colored root with a black carrot variety Kashi Krishna (VRCAR-126). The newly developed CMS line VRCAR-252 (A-Line, IC0642961) is very uniform to its maintainer Kashi Krishna (B-Line or Maintainer Line, IC0623130) for leaf & root morphology and has better heterotic potential for root yield, uniformity and anthocyanins content.

The qualitative traits of CMS line VRCAR-252 and its maintainer Kashi Krishna are uniform such as black colored root & core, purplish-green colored leaf, purple colored petiole, root shape of Danvers type (Tapering), bears purplish-white flowers in an umbel and ready to seed harvest in about 4.5 months after transplanting of stecklings. Moreover, the morphological and nutritional traits (pooled values for 2019-20 & 2020-21) of CMS line VRCAR-252 and its maintainer Kashi Krishna was statistically at par for grass plant weight (165.3 & 160.4 g, respectively), root length (23.9 & 23.4 cm, respectively), root weight (115.6 & 108.7 g, respectively), shoulder diameter (4.57 & 4.35 cm, respectively), root yield potential (276 & 265 q/ha), days to 50% flowering (62.4 & 55.2 days, respectively), plant height at flowering (125.6 & 128.5 cm, respectively), anthocyanins content (278 & 282 mg/100 g FW, respectively), phenolics content (323 & 311 mg GAE/100 g FW, respectively) and flavonoids content (143 & 140 mg CE/100 g FW, respectively); having better anthocyanin yield potential (67 & 69 kg/ha, respectively); and greater antioxidative ability (FRAP value of 47 & 44  $\mu\text{mol TE/g FW}$ , respectively). However, Singh *et al.* (2018) and Song *et al.* (2010) estimated the antioxidative ability of carotenoid carrots (red/orange/yellow) and red beetroot as FRAP value of 1.22 to 2.30 & 4.0 to 12.5  $\mu\text{mol TE/g FW}$ , respectively. It reveals that the newly developed CMS line VRCAR-252 & its maintainer Kashi Krishna is one of the richest sources of anthocyanins & phenolics; and possesses very high antioxidant ability i.e. about 28 and 7 times higher than carotenoid carrots and red beetroot, respectively.

An ideal CMS line should flower at the same time or a few days earlier than its maintainer line to get proper pollination and maximum seed set in the CMS line, and also, it should be slightly shorter in height for abundant availability of pollen grains. Days to 50% flowering and plant height at the flowering stage is shorter and smaller for the newly developed CMS line and its maintainer i.e.

ideally synchronous in flowering/pollination activities. Furthermore, the commercial  $F_1$  hybrid seed of carrot could produce very economically by transplanting stecklings of Female: Male parents in a ratio of 4:2 and managing adequate bee hives for proper pollination. Realizing the importance of antioxidative and heterotic potential, the newly developed CMS line of black carrot 'VRCAR-252' has been registered as unique germplasm (INGR22088, IC0642961 & IC0623130) by PGRC, ICAR-NBPGR, New Delhi on 8<sup>th</sup> July 2022.

In conclusion, hybrid breeding by utilizing black-colored CMS line VRCAR-252 would be very effective in harnessing the heterotic potential and thereby increasing the root yield, uniformity for root morphology & maturity, anthocyanins content (color intensity), antioxidative ability, and cost-effective commercial hybrid seed production of carrot.

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