

Studies on contribution of umbel order on seed yield and quality under different planting ratio and plant spacing in carrot hybrid, Pusa Vasuda

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Abstract

An experiment was conducted to study the contribution of different order of umbels to carrot hybrid seed yield and seed quality under different planting ratio and plant spacing. The experiment was conducted with the parental lines of carrot hybrid Pusa Vasuda. The experiment consisted of two planting ratio of 1:6 and 1:4 (pollen parent: seed parent) and five different plant spacing of the seed parent viz. 60 cm × 20 cm, 60 cm × 30 cm, 60 cm × 40 cm, 60 cm × 50 cm and 60 cm × 60 cm. The results revealed that umbel order had a significant effect on carrot seed yield and quality. Contribution of secondary umbel to seed yield/plant was maximum (65.1 % and 65% in 1:6 and 1:4, respectively) followed by primary (29.3% and 29.2% in 1:6 and 1:4, respectively) and tertiary umbel (5.6% and 5.8% in 1:6 and 1:4, respectively). Seeds from primary umbels were better in seed quality characteristics such as mean germination (71.7% and 72.2% in 1:6 and 1:4, respectively), mean thousand seed weight (2.162 g and 2.17 g in 1:6 and 1:4, respectively) and mean seedling length (16.7 cm in both 1:6 and 1:4).

Keywords: Carrot Hybrid, Umbel, Seed Yield, Seed Quality, Spacing

Introduction

Seed yield and quality are important factors to determine the profitability of hybrid seed production in carrot. Although, carrot have been widely cultivated since long in India, yet its yield per acre remains low and hence, there is considerable scope to increase the production potential by ensuring the uniform germination and enhance the production of higher marketable root. The

growth of carrot plant is indeterminate producing the central inflorescence known as primary umbel which is larger and the topmost umbel. It is followed by other subordinate branches of secondary, tertiary and other higher order umbels which keeps developing sequentially throughout the growing season. There are variable reports that umbel order has an important role in seed yield and quality (Pereira et al. 2008). Seeds obtained from primary umbels were reported to have higher seed germination and 1000 seed weight (Szafirowska 1994). It was also reported that seed yield was positively correlated with number of secondary umbels per plant (El Adgham et al. 1995). The relationships between plant density, seed yield and quality have been well established by various workers such as Gray (1981), Gray and steckel (1983), Malik et al.(1983), Noland et al. (1988) and Oliva et al.(1988). It was proposed by Gray (1981) that high plant densities should be used for carrot seed production as it will increase the proportion of seed from primary umbels. Therefore, the research experiment was planned and undertaken to study the contribution of different order of umbels under different planting ratios and plant spacing to seed yield and quality.

Materials and Methods

An experiment was carried out for two consecutive years during Rabi of season 2014-15 and 2015-16 at seed production unit farm of ICAR-IARI, New Delhi in randomised block design (RBD) with three replication. The experimental material consisted of the parental lines of tropical carrot hybrid PusaVasuda transplanted in month of July. The stecklings of pollen and seed parents were planted in two ratios 1:6 and 1:4. The female parent was planted with five plant spacing viz. 60 cm × 20 cm, 60 cm × 30 cm, 60 cm × 40 cm, 60 cm × 50 cm and 60 cm × 60 cm. The plant spacing of the male parent was kept constant at 60 cm × 30 cm. A basal dose of potassium (125 kg ha⁻¹), phosphorous (100 kg ha⁻¹) and half dose of nitrogen (50 kg ha⁻¹) were applied at the

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time of transplanting, while the remaining dose of nitrogen (50 kg ha^{-1}) was applied after 30 days of transplanting. Irrigation was given at 10 to 12 days interval as required. The crop was kept weed free through hand weeding which were carried out time to time during the crop growth. Hoeing and earthing-up was done after hand weeding. Ten randomly selected plants were tagged in each plot. Observations on number of secondary and tertiary umbels per plant on ten tagged plants were recorded. Data for umbel diameter, contribution by different umbel order to seed yield per plant was collected from primary, secondary and tertiary umbels of the ten tagged plants in each plot. Primary, secondary and tertiary umbels of tagged plants in each plots were harvested separately by hand at maturity. Seed quality parameters such as germination and 1000 seed weight were calculated as per ISTA guidelines, 2012. Vigour index 1 was calculated as suggested by Abdul-Baki and Anderson (1973). The data recorded during the two years was pooled and analysed statistically using Web Agri Stat Package (WASP) software.

Results and Discussion

Plant spacing had a significant effect on number of secondary and tertiary umbels per plant but the effect of planting ratio was non-significant (Table 1). Higher secondary and tertiary umbels were obtained under

spacing of $60 \text{ cm} \times 60 \text{ cm}$ which was 10.6 and 22 under planting ratio 1:6 and in 1:4 it was 10.6 and 22.6, respectively. The number of secondary and tertiary umbels decreased progressively as the plant spacing decreased. In general, the number of secondary umbel was less than tertiary under all spacing. The interaction between plant spacing and different order of umbels was also found to be significant. Under higher plant spacing there was profuse branching and less competition for nutrients and sunlight which lead to more number of secondary and tertiary umbels.

Umbel diameter varied significantly among the three different umbel orders whereas the variation in diameter in the different plant spacing and its interaction with umbel order was found to be non significant (Table 1). Primary umbel had higher mean umbel diameter (9.2 cm and 8.9 cm in 1:6 and 1:4 planting ratio respectively) followed by secondary (6.6 cm and 6.4 cm under 1:6 and 1:4 planting ratio respectively) and tertiary umbel (3.5 cm in both 1:6 and 1:4). Secondary umbels contributed most to seed yield /plant (65.1 % and 65% in 1:6 and 1:4 respectively) followed by primary (29.3% and 29.2% in 1:6 and 1:4 respectively) and tertiary umbels (5.6% and 5.8% in 1:6 and 1:4 respectively) (Table 1). Plant spacing also played a significant role. As the spacing increased from $60 \text{ cm} \times 20 \text{ cm}$ to $60 \text{ cm} \times 60 \text{ cm}$ the contribution of primary umbel to total seed yield per plant decreased from 42.3% to 21.8%

Table 1: Effect of row ratio, plant spacing and umbel order and their interactions on flowering and seed yield attributes of seed parent of carrot cv Pusa Vasuda.

Treatment	Number of umbels per plant		Umbel diameter (cm)		Contribution by different umbel to seed yield/plant (g)			Percent Contribution by different umbel to seed yield/plant			
Planting ratio (1:6)	SU	TU	PU	SU	TU	PU	SU	TU	PU	SU	TU
60cm×20cm	6.6	11	9.4	6.5	3.6	2.58	3.31	0.22	42.3(40.8)	54(47.3)	3.7(11.1)
60cm×30cm	8.5	16	8.7	6.7	3.6	2.66	5.06	0.41	32.7(34.9)	62.3(52.1)	5(12.9)
60cm×40cm	8.8	18.3	8.8	6.4	3.3	2.7	6.75	0.63	27.3(31.5)	66.6(54.7)	6.1(14.3)
60cm×50cm	10.3	20.6	9.5	6.9	3.3	2.76	8.6	0.82	22.3(28.2)	70.9(57.4)	6.8(15.1)
60cm×60cm	10.6	22	9.4	6.3	3.5	2.83	9.22	0.85	21.8(27.8)	71.4(57.7)	6.8(15.1)
Mean	9	17.6	9.2	6.6	3.5	2.58	3.31	0.22	29.3(32.8)	65.1(53.7)	5.6(13.8)
Planting ratio (1:4)											
60cm×20cm	6.6	11.1	9	6.4	3.5	2.62	3.35	0.26	42.2(40.5)	53.7(47.1)	4.1(11.7)
60cm×30cm	8.3	16.5	8.5	6.6	3.5	2.67	5.15	0.43	32.4(34.7)	62.5(52.2)	5.1(13.1)
60cm×40cm	8.5	20.1	8.8	6.2	3.5	2.71	6.8	0.65	26.7(31.1)	66.9(54.9)	6.4(14.7)
60cm×50cm	10.3	21.3	9.1	6.5	3.3	2.81	8.82	0.86	22.5(28.3)	70.7(57.2)	6.8(15.1)
60cm×60cm	10.6	22.6	9.1	6.5	3.5	2.87	9.27	0.87	22(27)	71.3(57.6)	6.7(15)
Mean	8.9	18.4	8.9	6.4	3.5	2.74	6.68	0.61	29.2(32.7)	65(53.7)	5.8(13.9)
						CD=5%					
Planting ratio (R)	NS		NS		NS		NS		NS		
Plant spacing (S)	0.732		NS		0.125		NS		NS		
Umbel order (U)	0.463		NS		0.097		0.546		NS		
R×S	NS		NS		NS		NS		NS		
R×U	NS		NS		NS		NS		NS		
S×U	1.035		NS		0.217		1.22		NS		
R×S×U	NS		NS		NS		NS		NS		

Figures in parenthesis represents arc sine transformed values of percentage data, PU-primary umbel, SU- secondary umbel, TU- tertiary umbel, NS-non significant

and 42.2% to 22% in 1:6 and 1:4 respectively while it increased in case of secondary from 54% to 71.4% and 53.7% to 71.3% in 1:6 and 1:4 respectively and tertiary from 3.7% to 6.8% and 4.1% to 6.7% in 1:6 and 1:4 respectively. The interaction between umbel order and spacing for seed yield was also significant.

There was significant effect of umbel order on seed germination whereas the variation in percent seed germination in different plant spacing and planting ratios and their interaction with umbel order was non-significant (Table 2). Mean germination was highest in seeds of primary umbels (71.7% and 72.2% in 1:6 and 1:4, respectively) followed by secondary (63.9% and 63.5% in 1:6 and 1:4 planting ratios, respectively) and tertiary (34.3% in both 1:6 and 1:4) umbels. Primary umbels had significantly highest mean 1000 seed weight (2.162 gm and 2.17 gm in 1:6 and 1:4 respectively) followed by secondary (1.779 gm and 1.788 gm in 1:6 and 1:4 respectively) and tertiary (1.36gm in both 1:6 and 1:4) (Table 2). Variation in 1000 seed weight under different plant spacing was also found to be significant but their interaction effect was non-significant. Seed vigour index 1 also showed significant variation between different orders of umbels. Seeds of primary umbels gave seeds with mean highest vigour (1202 and 1210 in 1:6 and 1:4 planting ratios, respectively) followed by secondary (917 and 914 in 1:6 and 1:4 respectively) and tertiary (379 and 378 in 1:6 and 1:4 respectively) umbels. Variation in seed vigour index 1 under different

plant spacing and its interaction with umbel order was non-significant. Seedling length also showed significant variation between different orders of umbels. Seeds of primary umbels gave seeds with highest mean seedling length (16.7cm in both 1:6 and 1:4) followed by secondary (14.5cm and 14.4cm in 1:6 and 1:4 respectively) and tertiary (11cm and 10.9cm in 1:6 and 1:4 respectively) umbels.

As the primary umbels are the first to flower, dry matter accumulation occurs more efficiently during the seed filling stage than other higher order umbels that results in higher thousand seed weight. Later manifests into better germination, vigour and seedling characteristics such as its length and dry weight. Other probable causes for better quality of seeds of primary umbels are due to the higher concentration of antioxidant enzymes. Silva et al. (2016) reported that seeds obtained from the primary and secondary umbels displayed a higher rate of germination than from the tertiary umbels with the seeds from the primary umbels showing high activity for peroxidase, catalase and superoxide dismutase, and low activity for the enzyme ascorbate peroxidase. Seed yield and its quality, both are important for successful commercial seed production of vegetable crops. The goal of increasing plant densities in carrot seed production is to increase the contribution of primary umbels which are better in seed quality to the total seed yield while decreasing the lateral growth of secondary and tertiary branches due to increased competition

Table 2: Effect of row ratio, plant spacing and umbel order and their interactions on seed vigour in seed parent of carrot cv. Pusa Vasuda.

Treatment	Seed germination (%)			1000 seed weight (g)			Vigour Index 1			Seedling length (cm)		
Planting ratio (1:6)	PU	SU	TU	PU	SU	TU	PU	SU	TU	PU	SU	TU
60×20 cm	71.2(57.5)	62.8(52.4)	33.2(35.2)	2.14	1.757	1.347	1167	921	362	16.4	14.7	10.9
60×30 cm	71.5(57.7)	63.7(53)	33.2(35.2)	2.157	1.778	1.352	1202	896	378	16.8	14.1	11.1
60×40 cm	71.8(57.9)	64(53.1)	34.7(36.1)	2.16	1.78	1.36	1194	889	385	16.6	13.9	11.1
60×50 cm	72(58.1)	64.3(53.3)	35(36.3)	2.175	1.79	1.367	1232	933	387	17.1	14.5	11.1
60×60 cm	72.2(58.2)	64.7(53.1)	35.2(36.4)	2.178	1.79	1.375	1217	948	387	16.9	14.7	11
Mean	71.7(58.9)	63.9(53.1)	34.3(35.8)	2.162	1.779	1.36	1202	917	379	16.7	14.5	11
Planting ratio (1:4)												
60×20 cm	71.5(57.7)	63.2(52.7)	32.7(34.9)	2.152	1.77	1.353	1172	925	357	16.5	13.8	10.7
60×30 cm	72(58.1)	63.5(52.8)	33.8(35.5)	2.173	1.79	1.36	1211	894	374	16.9	14.6	10.9
60×40 cm	72.8(58.6)	63.7(53)	35.2(36.4)	2.172	1.793	1.36	1209	893	391	16.7	14.4	11.2
60×50 cm	72.3(58.2)	63.8(53)	35.2(36.4)	2.178	1.797	1.363	1237	927	389	17	14.7	11
60×60 cm	72.5(58.4)	63.5(52.9)	34.5(36)	2.178	1.79	1.365	1223	931	379	16.7	14.4	11.1
Mean	72.2(58.2)	63.5(52.8)	34.3(35.8)	2.17	1.788	1.36	1210	914	378	16.7	14.4	10.9
				CD=5%								
Planting ratio (R)		NS			NS			NS			NS	
Plant spacing (S)		NS			0.01			NS			NS	
Umbel order (U)		0.385			0.008			13.89			0.008	
R×S		NS			NS			NS			NS	
R×U		NS			NS			NS			NS	
S×U		NS			NS			NS			NS	
R×S×U		NS			NS			NS			NS	

Figures in parenthesis represents arc sine transformed values of percentage data, PU-primary umbel, SU- secondary umbel, TU- tertiary umbel, NS-non significant

among plants there by reducing the contribution of higher order umbels that exhibits poor seed quality. Although under wider spacing of 60cm×60cm higher number of secondary and tertiary umbels and higher yield per plant are obtained but the contribution of primary umbels to total seed yield drops significantly from 42.3% to 22%. Since planting ratio and plant spacing didnot have any significant effect on seed quality traits, lower plant spacing can be used for hybrid seed production of carrot. Also seed lots could be graded in terms of higher seed germination and vigour by harvesting primary umbels separately from secondary and tertiary umbels and selling at a higher price. This could also be useful for meeting international standards for export of seeds.

सारांश

पौधरोपण अनुपात और पौध अंतराल के तहत गाजर संकर बीज उपज और बीज की गुणवत्ता के लिए विभिन्न पुष्पछत्र के योगदान का अध्ययन करने के लिए एक प्रयोग किया गया। 2014–15 और 2015–16 के दौरान आईसीएआर-आईएआरआई, नई दिल्ली में गाजर संकर पुसा वसुदा की पैतृक लाइनों के साथ प्रयोग किया गया। प्रयोग में 1:6 और 1:4 (पराग पौधे: बीज पौधे) के दो रोपण अनुपात और बीज पौधे के पांच अलग-अलग पौध अंतराल (60 × 20 सेन्टी मीटर, 60 × 30 सेन्टी मीटर, 60 × 40 सेन्टी मीटर, 60 × 50 सेन्टी मीटर और 60 × 60 सेन्टी मीटर) शामिल थीं। परिणाम बताते हैं कि विभिन्न प्रकार के पुष्पछत्र की वजह से गाजर बीज उपज और गुणवत्ता पर महत्वपूर्ण प्रभाव पड़ता है। प्राथमिक पुष्पछत्र (1:6 और 1:4 में क्रमश 2 9.3 प्रतिशत और 2 9.2 प्रतिशत) और तृतीयक पुष्पछत्र (1:6 और 1:4 में क्रमश 5.6 प्रतिशत और 5.8 प्रतिशत) की तुलना में द्वितीयक पुष्पछत्र ने बीज उपज/पौधे (1:6 और 1:4 में क्रमश: 65.1 प्रतिशत और 65 प्रतिशत) में सबसे अधिक योगदान दिया। प्राथमिक पुष्पछत्र के बीज, बीज गुणवत्ता विशेषताओं में बेहतर थे जैसे कि अंकुरण (1:6 और 1:4 में क्रमश 71.7 प्रतिशत और 72.2 प्रतिशत), हजार बीज वजन (1:6 और 1:4 में क्रमश 2.162 ग्राम और 2.17 ग्राम), और अंकुर लंबाई (1:6 और 1:4 में 16.7 सेन्टी मीटर)।

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