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RESEARCH ARTICLE

EFFECT OF SPACING'S AND FERTILIZERS ON SEED YIELD, ITS ATTRIBUTES AND QUALITY OF OKRA [*ABELMOSCHUSESCULANTUS* (L.)MOENCH]

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ABSTRACT

The experiment comprised of three spacing & fertilizer levels and two varieties was conducted during spring summer season of 2013-14 at Research Farm of Vegetable Science, CCS Haryana Agricultural University Hisar to study the effect of spacing and fertilizers on seed yield its attribute seed quality in okra. The seed yield and yield attributes were significantly affected by spacing, fertilizer and varieties. The maximum seeds per fruit, test weight, seed yield (q/ha), germination (%), seedling length (cm), seedling dry weight (g),seed vigour index I and II, tetrazolium test (%), dehydrogenase activity (OD), electrical conductivity (dSm^{-1})and seed density (g/cc) were achieved in variety HisarUnnat at spacing of 30 x 15 cm with the fertilizer levels of 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O per hectare. However, maximum length and diameter of mature fruitwere observed in variety HBT-49-1 atspacing of 30 x 15 cm with fertilizer levels of187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O per hectare.

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INTRODUCTION

Okra, *Abelmoschusesculantus* (L.) Moench, is one of the most important summer vegetable crop grown for its immature fruits. It has multiple uses. The extract of roots and stems are useful for cleaning cane juice in preparation of *jaggary* (Gur). The dry seeds contain 13-22% edible oil and 20-24% crude. The cake prepared from okra seeds is used as animal feed. The dry fruit shell and stem containing crude fiber suitable for use in manufacture of paper and cardboard (Dhankhar and Mishra, 2013).In India it is grown in both spring-summer (March-June) and rainy season (July-September). Okra is mainly grown in tropical and subtropical regions of world. But thrives best under hot and humid conditions. Hence, setting of fruits, seeds and their development is better during rainy season resulting in higher seed yield. In spring summer season, the prevailing temperature remains very high (>42°C) and low humidity (<50%) during spring summer season particularly in the month of May-June higher temperature production of pollengraimn is poor which affect the setting of seeds aversely. So the seed yield is low in spring season crop than rainy season. However, incidence of yellow vein mosaic virus (50-90% depending on crop growth stage) and infestation of shoot and fruit borer are very high (>50%), which affect both seed yield and its quality drastically.

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So keeping this in view, the experiment was conducted to study the effect of spacing and fertilizers on seed yield and its quality.

MATERIALS AND METHODS

The present study was carried out at the Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during spring-summer season, 2013-14. Hisar is situated between 29°10′ N latitude and 15° 46′E longitude at mean elevation of 215.2 meter above mean sea level, has a semiarid, sub-tropical climate, hot and dry winds during summer and dry severe cold in the winter are the common features of this region. The mean maximum and minimum temperature of 42° to 46°C is quite common during summer months (May-June). The rainfall is restricted mainly to the monsoon months from July to September, but sometime pre-monsoon showers occur in June also. The soil of this area is derived from Indo-Gangentic alluvium, which is very deep and sandy loam in texture. The pH of the soil varies from 7.8 to 8.9 since these soil are poor in organic carbon, available nitrogen, medium in phosphorus and rich in potash content.

The experimental material was comprised of two varieties, (HisarUnnat and HBT-49-1), three spacing (30 x 5 cm, 30 x 10 cm and 30 x 15 cm) and three fertilizers levels (150 kg N + 60 kg P_2O_5), (187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O) and (225 kg

N + 90 kg P_2O_5 + 60 kg K_2O) was laid out in split-split block design with three replications. In each replication, there were 18 plots and each plot was comprised of 3.6 m × 3 m size accommodating three rows. Recommended package of practices for other operations were followed to raise a healthy crop. The observations were taken on various parameters of seed yield, its attributes and seed quality parameters like seed yield (Q/ha), number of seed per fruit, test weight (g), length of mature fruit (cm), diameter of mature fruit (cm), germination (%), seedling length (cm), seedling dry weight (g), seed vigour index-(I&II), teterazolium test (%), dehydrogenase activity (OD), electrical conductivity (dSm^{-1}) and seed density (g/cc). The test weight (g) was measured in one thousand seeds replicated thrice in each treatment, weighed and average seed weight of each treatment was calculated. Standard germination (%) was measured according to the rules of International Seed Testing Association (ISTA, 1999). Seed vigour indices-I&II were calculated according to the method suggested by Baki and Anderson (1973). The tetrazolium test (%) was measured after removal of seed coat the seeds were stained in 0.5% tetrazolium solution (2, 3, 5-triphenyl tetrazolium chloride) for 4 hrs. at 38°C and examined under magnifications. The number of seeds stained entirely red were considered as normal viable seeds and expressed in percentage according to Moore, 1985.

RESULTS

Effect of spacing on seed yield and its attributes

The maximum seed yield per hectare (12.28 q/ha) was produced when crop was sown at the spacing of 30 x 15 cm, which was significantly higher than the spacing of 30 x 5 cm (9.92 q/ha) and at par with 30 x 10 cm (11.27q/ha). revealed the similar results with the present study in which plant to plant spacing of 60 x 40 cm produced the highest seed yield of okra (2.86 t/ha) followed by 60 x 30 cm spacing (2.80 t/ha). Similar trend was also observed for number of seed per fruit at spacing 30 x 15 cm (63.27) as compared to spacing 30 x 10 cm (60.68) and 30 x 5 cm (55.70) in okra. Magagula and Ossom, (2011) also observed that the plant density was not affecting the number of seeds per pod. However, highest fruit length (15.40cm) was observed at closer spacing (30 x 5 cm), which was significantly higher than wider spacing (30 x 15cm). Maximum seed yield at spacing of 30 x 15 cm might be due to maximum number of seeds per fruit and weight of seeds at the same spacing as seed yield depend on these traits. The higher seed weight at wider spacing were result of more availability of nutrients, moisture and sunlight to plants in comparison to closer spacing. Moniruzzaman *et al.* (2007) also obtained higher seed yield & seeds per fruit at wider spacing of plant to plant. The results are in conformity with Abdul *et al.* (2007) and Rao *et al.* (2004).

Effect of spacing on seed quality

The result revealed that standard germination percentage influenced by spacing. The standard germination percentage was observed maximum (79.64%) at spacing 30 x 15 cm, which was significantly higher than spacing of 30 x 10 cm (77.04%) and 30 x 5 cm (76.27%). No significant difference for germination was found between spacing of 30 x10 cm and 30 x 5 cm. Sharma *et al* (2012) also reported that plant density had significant effect on standard germination percentage. Wider spacing between plant to plant (60 x 30 cm) proved better than the closer spacing (60 x 20 cm). The seed vigour index-II also showed same trend as standard germination percentage. Although the germination was higher at 30 cm x 15 cm, but seedling length was statistically same in both the spacing 30 x 15 cm and 30 x 10 cm as compare to spacing 30 x 5 cm. The spacing 30 x 15 cm and 30 x 10 cm were at par with each other in the term of seedling dry weight but differ significantly from 30 x 5 cm spacing. The results are in conformity with Manoj *et al.* (2007) and Adebayo *et al.* (2013). Seed vigour index-I is based on the standard germination percentage and seedling length. Higher the germination percentage, higher will be the seedling length. On the basis of this, seed vigour index-1 of okra was studied with spacing, fertilizer and variety. In case of spacing 30 cm x 15 cm higher seed vigour index was observed followed by 30 cm x 10 cm spacing which were at par with each other, but significantly differ from 30 cm x 5 cm. The significantly superior value of seed vigour index-I was recorded at wider spacing 60 x 30 cm over closer plant spacing 45 x 20 cm. Sharma *et al.* (2012) and Moniruzzaman and Quamruzzaman (2009).

The spacing of 30 x 15 cm produced significantly highest viable seed as compare to spacing of 30 x 10 cm and 30 x 5 cm decided the higher seed viability. Dehydrogenises activity was significantly higher in spacing 30 x 15 cm as compared to spacing of 30 x 10 cm and 30 x 5 cm, respectively. Electrical conductivity was significantly highest in spacing 30 x 15 cm as compare to spacing 30 x 10 cm and 30 x 5 cm. But spacing 30 x 10 cm and 30 x 5 cm were at par with each other. The seed density was highest in spacing 30 x 15 cm as compare to spacing 30 x 10 cm and 30 x 5 cm. Rao *et al.* (2004) also reported tha maximum seed density was observed in bold seeds harvested from lower nodes (P,S,) *i.e.*, 66.21 g (Kharif) and 69.30 g (summer) followed by P, S, I, P and S while lowest (8.56 & 10.45 g) in P, S class reported by These results are also in conformity with the Sharma *et al.* 2012, Dhankhar *et al*. (2012).

Effect of fertilizers on seed yield and its attributes

The maximum seed yield (12.23 q/ha) was obtained with the application of 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O, which was significantly higher (9.99 q/ha) than the recommended dose of fertilizers (150 kg N + 60 kg P_2O_5) and statistically at par with fertilizers dose of 225 kg N + 90 kg P_2O_5 + 60 kg K_2O per hectare.

This might be due to the fact that phosphorus indirectly affected the seed yield as it enhances the uptake of nitrogen. According to the mentioned results, El-Waraky, (2014). obtained highest seed yield in new okra variety with the application of 45 kg P_2O_5 per hectare than control in mid April sown crop.

Test weight of seed and diameter of mature fruits also showed the same trends as total seed yield. (Bhat and Dhar, 1999) also observed similar fashion for test weight & diameter of fruits.

Table 1. Effect of spacing and fertilizer levels on seed yield and its attributes of okra varieties Hisar Unnat and HBT-49-1

Treatments	Seeds per fruit (no.)	Length of mature fruit (cm)	Diameter of mature fruit (cm)	Test wt. of 1000 seeds (g)	Seed yield (Q/ha)
		Spacing			
S_1: 30 cm x 5 cm	55.70	15.70	1.90	60.76	9.92
S_2: 30 cm x 10 cm	60.68	15.48	2.09	62.58	11.27
S_3: 30 cm x 15 cm	63.27	15.01	2.14	64.11	12.28
SEm±	1.01	0.09	0.04	0.65	0.22
CD at 5%	3.95	0.36	0.14	1.96	0.86
		Fertilizer			
F_1: 150 kg N + 60 kg P_2O_5	57.86	15.07	1.97	61.38	9.99
F_2: 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O	62.01	15.96	2.12	64.08	12.23
F_3: 225 kg N + 90 kg P_2O_5 + 60 kg K_2O	59.79	15.15	2.04	61.99	11.24
SEm±	0.70	0.13	0.02	0.76	0.38
CD at 5%	2.17	0.39	0.06	2.19	1.17
		Varieties			
V_1: HisarUnnat	61.79	15.18	1.97	63.85	11.99
V_2: HBT-49-1	57.99	15.61	2.12	61.11	10.33
SEm±	0.83	0.14	0.04	0.62	0.20
CD at 5%	2.46	0.42	0.14	1.79	0.60

Table 2.Effect of spacing and fertilizer levels on seedling quality of okra varieties HisarUnnat and HBT-49-1

Treatments	Germination (%)	Seedling length (cm)	Seedling dry wt. (g)	Seed vigour index	
				I	II
		Spacing			
S_1: 30 cm x 5 cm	76.27	33.38	0.403	23.96	0.294
S_2: 30 cm x 10 cm	77.04	35.42	0.411	26.51	0.312
S_3: 30 cm x 15 cm	79.64	36.16	0.423	27.57	0.338
SEm±	0.66	0.36	0.005	0.46	0.006
CD at 5%	1.90	1.08	0.014	1.38	0.018
			Fertilizer		
F_1: 150 kg N + 60 kg P_2O_5	76.38	34.12	0.403	23.68	0.303
F_2: 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O	80.18	35.96	0.427	27.89	0.331
F_3: 225 kg N + 90 kg P_2O_5 + 60 kg K_2O	76.39	34.88	0.406	25.80	0.311
SEm±	0.73	0.43	0.006	0.55	0.005
CD at 5%	2.10	1.24	0.016	1.59	0.015
			Varieties		
V_1: HisarUnnat	78.89	35.60	0.423	26.92	0.321
V_2: HBT-49-1	76.41	34.37	0.401	24.66	0.309
SEm±	0.60	0.35	0.005	0.45	0.004
CD at 5%	1.71	1.01	0.013	1.29	0.012

Table 3. Effect of spacing and fertilizer levels on seed quality of okra varieties Hisar Unnat and HBT-49-1

Treatments	Teterazolium test (%)	Dehydrogenises activity (OD)	Electrical conductivity	Seed density (g/cc)
Spacing				
S_1: 30 cm x 5 cm	78.58	1.64	0.894	1.67
S_2: 30 cm x 10 cm	82.10	1.99	0.910	1.71
S_3: 30 cm x 15 cm	85.15	2.11	0.938	1.72
SEm±	0.70	0.02	0.006	0.01
CD at 5%	2.10	0.07	0.018	0.04
Fertilizer				
F_1: 150 kg N + 60 kg P_2O_5	79.12	1.66	0.903	1.66
F_2: 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O	84.77	2.06	0.931	1.73
F_3: 225 kg N + 90 kg P_2O_5 + 60 kg K_2O	81.94	2.04	0.911	1.71
SEm±	0.83	0.06	0.005	0.02
CD at 5%	2.39	0.18	0.015	0.06
Varieties				
V_1: HisarUnnat	83.95	1.96	0.921	1.72
V_2: HBT-49-1	79.94	1.87	0.909	1.68
SEm±	0.68	0.03	0.004	0.01
CD at 5%	1.95	0.08	0.012	0.02

Highest number of seeds per fruit (62.01) and length of mature fruit (15.96 cm), was observed significantly higher with the application of 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O per hectare than application of 150 kg N + 60 kg P_2O_5 and 225 kg N + 90 kg P_2O_5 + 60 kg K_2O. Phosphorus help in setting and development seed as well as its compounded act as energy currency within the plant. The similar results seemed to be in accordance with the El-Waraky *et al*. 2014 they reported that the phosphorus fertilization with 45 kg P_2O_5 $fed.^{-1}$, significantly, increased seed yield per plant, number of seeds per pod, seed yield per pod, weight of 100 seeds, pod length, diameter and seed germination percentage in the both seasons, as compared with 15 or 30 kg P_2O_5/ha.

Effect of fertilizers on seed quality

Application of fertilizer with rate of 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O per hectare resulted in significantly higher germination percentage (80.18%) compare to 225 kg N + 90 kg P_2O_5 + 60 kg K_2O (76.39) and 150 kg N + 60 kg P_2O_5 (76.38). which is similarly to the findings of Kumar *et al.* (2014). The fertilizer levels 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O produced higher seedling length (35.96 cm) and seedling dry weight (0.43 g) as compare to fertilizer levels 225 kg N + 90 kg P_2O_5 + 60 kg K_2O and150 kg N + 60 kg. The seed vigour index-I (27.89) and seed vigour index-II (0.331) was found highest in application of fertilizer 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O as compared to fertilizer dose of 225 kg N + 90 kg P_2O_5 + 60 kg K_2O and recommended dose of fertilizer 150 kg N + 60 kg P_2O_5 in okra. The seedling vigour index length was recorded with the numerically maximum value by the variety Shakti (3242.74) followed by Bhendi Anjali (3144.34) and the minimum seedling vigour index length value by variety Arka Anamika (1960.46) with mean value (2693.948). The vigour index mass was recorded with the numerically maximum value by the variety sivam (24.69) followed by Bhendi Anjali (23.96) and the minimum seedling vigour index mass value by variety ArkaAnamika (14.99) with mean value (20.73). These results are similarly to the findings of Perry (1972) and Yakkala *et al.* (2015).

The highest values of tetrazolium test (84.77%) and electrical conductivity (0.931dSm^{-1}) was found at 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O per hectare dose of fertilizers, which was significantly higher than recommended and 225 kg N + 90 kg P_2O_5 + 60 kg K_2O per hectare dose of fertilizers. The electrical conductivity of seed was recorded with the numerically maximum value by the variety ArkaAnamika (1.435 dSm-1) variety followed by Ts-931(1.04 dSm-1) and the minimum electrical conductivity of seed value by the variety Shakti (0.39 dSm-1) with mean value (1.00 dSm-1) and these results are similarly to the findings of Tenford and Kaune *et al*. (1987), Kiros *et al*. (2008)., Vashisth and Nagarajan (2010), Kumar *et al.* (2014) and Yakkala *et al.* (2015). The dehydrogenises activity (2.06 OD) and seed density (1.73 g/cc) of okra seeds recorded at fertilizer level 187.5 kg N + 75 kg P_2O_5 + 60 kg K_2O was at par with 225 kg N + 90 kg P_2O_5 + 60 kg K_2O dose of fertilizer but resulted significantly higher recommended. Similarly, treatments T7, T8, T9, T2 and T1 substantially enhanced dehydrogenase activity over control in L1 lot of the variety HG-563, whereas in L2 lot treatments T1, T2 and T3 enhanced the dehydrogenase activity over control. Steiner *et al.* (1989) reported that dehydrogenase enzyme activity test was found the best predictor of seedling emergence in wheat. Similar correlations and results were also reported by Kharb *et al*. (1994), Krishnappa *et al.* (1999) and Yakkala *et al.* (2015) in various crops and were conformity with Moniruzzaman and Quamruzzamam, (2009) and Magagula and Ossom, (2011).

Performance of variety for seed yield and its traits

The variety HisarUnnat produced significantly higher seed yield (11.99 q/ha) as compare to HBT-49-1 (10.33) variety of okra. The number of seeds per fruit was highest in variety HisarUnnat (61.79 g) as compare to variety HBT-49-1 (57.99g). The length and diameter of mature fruit was significantly higher in variety HBT-49-1 (15.61, 2.12 cm) as compare to HisarUnnat (15.18, 1.97 cm) variety of okra. Variety HisarUnnat produced significantly highest test weight (63.85g) better than HBT-49-1 (61.11g) variety of okra. These results are similarly to the findings of Yakkala *et al.* (2015) and Yahyaei *et al.* (2007). The higher seed might be due to higher number of seeds per fruit and test weight of seed in HisarUnnat. So, variety HisarUnnat should be considered for seed production in summer season as this variety also perform better than HBT49-1 for all seed quality under study. Hosamani, (2008) also reported that test weight and number of seeds per fruit contribute to higher seed yield per hectare, which is similar to findings of Iqbal *et al.* (2001).

Effect on seed quality parameters

All the seed quality parameters were significantly higher in Hisar Unnat as compare to HBT-49-1. The germination percentage was recorded with the numerically maximum value by the variety Bhendi Anjali (92%) followed by Shakti (90.50%) and with minimum germination percentage value by the variety ArkaAnamika (70.50%) with mean value (83.05%) and these results are similarly to the findings of Yakkala *et al.* (2015). Tetrazolium test is 5.02% higher in HisarUnnat over HBT-49-1. The seedling length (35.60 cm), dry weight (0.42 g), seed vigour index-I (26.92), vigour index- II (0.32), dehydrogenises activity (1.96 OD), electrical conductivity (0.92 dSm^{-1}) and seed density (1.72 g/cc) were higher in variety HisarUnnat as compared to HBT-49-1 variety of okra which were 34.37 cm, 0.40 g, 24.66, 0.30, 1.87, 0.90 and 1.68, respectively. The results were in conformity with Iqbal *et al.* (2001).

Conclusion

Both varieties HisarUnnat and HBT-49-1 resulted in significant higher seed yield (q/ha), its attributes like seed per fruit, length, diameter of mature fruit, test weight and seed quality parameters like germination, seedling length, seedling dry weight, seed vigour index-I and II, tetrazolium test, dehydrogenises activity, electrical conductivity and seed density at sown of spacing of 30 x 15 cm with the fertilizer application of (187.5kg N + 75 kg P_2O_5 + 60 kg K_2O) per hectare. Hisar Unnat gave better performance for all traits except length of mature fruit and diameter of mature fruit than HBT-49-1

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