



QUALITY OF FENNEL AS INFLUENCED BY PLANT DENSITY, FERTILIZATION AND PLANT GROWTH REGULATORS

B.L. MENARIA¹ AND P.L. MALIWAL^{2*}

Maharana Pratap University of Agriculture and Technology, Udaipur 313 001

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SUMMARY

A field experiment was conducted during the year 2002-03 and 2003-04 at Instructional Farm, Rajasthan College of Agriculture, Udaipur. The results revealed that planting of fennel at a density of 27.77 thousand plants ha⁻¹ produced seeds which were superior in chlorophyll content, appearance and total soluble sugars over the seed obtained from the densities of 55.55 and 83.33 thousand plant ha⁻¹. Application of 90 kg N + 40 kg P₂O₅ + 20 K₂O + 20 kg S + 5 kg Zn ha⁻¹ (NPKZnS) produced seeds, superior in all quality parameters over the NPK, NPKS and NPKZn treatments. Application of NAA at 100 ppm and BA at 10 ppm significantly improved total chlorophyll content, total soluble sugars, protein content and volatile oil content of fennel seeds over water sprays.

Key words: Benzyl adenine, Fennel, fertilizers, growth regulators, naphthalene acetic acid, plant density.

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) is widely grown throughout the temperate and subtropical regions of the world for its aromatic seeds used in preparation of food dishes such as soups, sauces, pastries, confectionaries, pickles, liquors, etc. The fennel seeds are aromatic, stimulant and carminative, useful in treating diseases of chest, spleen and kidney. Fennel oil is used as a flavouring agent in various culinary preparations, confectionary, cordials and liquors. The percentage of volatile oil in seeds varies from 1.5 to 3.5 per cent. The seed residue left after the extraction of essential oil is used as a cattle feed. It contains 14 -22 per cent protein.

In India, fennel is grown in an area of 39,900 hectares producing 38,500 tons seeds with an average productivity of 965 kg ha⁻¹ (Indian Horticulture Data Base, 2004). Rajasthan ranks second in area (9,539 ha)

with a productivity of 741 kg ha⁻¹. The productivity as well as quality of fennel is improved by agronomic manipulations. Keeping this in view, a field experiment was conducted to find out the effect of plant density, fertilization and plant growth regulators on quality of fennel.

MATERIALS AND METHODS

A field experiment was conducted during the year 2002-03 and 2003-04 at Instructional Farm, Rajasthan College of Agriculture, Udaipur. The treatments consisted of three plants densities (27.77, 55.55 and 83.33 thousand plants ha⁻¹), four fertilizer doses [90 kg N + 40 kg P₂O₅ + 20 kg K₂O (NPK), 90 kg N + 40 kg P₂O₅ + 20 kg K₂O + 20 kg S (NPKS), 90 kg N + 40 kg P₂O₅ + 20 kg K₂O + 5 kg Zn (NPKZn) and 90 kg N + 40 kg P₂O₅ + 20 kg K₂O + 20 kg S + 5 kg Zn (NPKSZn) ha⁻¹] and three plant growth regulators (water spray,

* Corresponding author, Present address: ¹Senior Research Fellow (Jatropha Project-Agronomy), Department of FMPE, CTAE, Udaipur email: drmenaria@gmail.com, ²Zonal Director Research, ARS, Udaipur.

benzyl adenine at 10 ppm (BA) and naphthalene acetic acid at 100 ppm (NAA). The experiment was laid out in split plot design with three replications. The crop was raised by transplanting methods. The nursery was raised in the last week of June using 4 kg seed ha⁻¹ of Gujarat fennel-2 variety and transplanted in the first fortnight of August.

One third of nitrogen, full dose of phosphorus, potash, sulphur and zinc were applied as basal dose before planting of fennel and remaining nitrogen was applied in two equal splits. While, growth regulators were sprayed at 35 and 70 days after transplanting.

To determine quality of seeds following methods were used. Total chlorophyll content of seeds (Moran and Porath 1980), Appearance based on visual scoring (0-9), total soluble sugars (Hodge and Hofrieter 1962), protein content (AOAC, 1960), volatile oil content (Tiwari

Table 1. Qualitative description of treatment effects on seed appearance on the visual scoring scale of 0-9.

Quality	Appearance	Rating
Poor	Brown to black	0
	Spotted	1
	Faded	2
	Blackish yellow	3
Moderate	Yellowish	4
	Yellowish green	5
	Very light green	6
Good	Light green	7
	Green	8
Excellent	Dark green	9

Table 2. Effect of plant density, fertilization and growth regulators on total chlorophyll content and appearance of fennel seed.

Treatment	Total chlorophyll content of seed (mg g ⁻¹)						Appearance (0-9 point scale)					
	First plucking			Second plucking			Third plucking					
	2002-03	2003-04	Pooled	2002-03	2003-04	Pooled	2002-03	2003-04	Pooled	2002-03	2003-04	Pooled
Plant Density (*000 ha⁻¹)												
27.77	0.2923	0.2961	0.2942	0.3743	0.3786	0.3765	0.3270	0.3291	0.3281	8.33	8.50	8.42
55.55	0.2697	0.2725	0.2711	0.3379	0.3396	0.3387	0.2951	0.2953	0.2952	7.42	7.39	7.40
83.33	0.2511	0.2516	0.2513	0.2999	0.2993	0.2996	0.2652	0.2656	0.2654	6.17	6.50	6.33
SEm ±	0.0031	0.0033	0.0023	0.0039	0.0036	0.0027	0.0032	0.0034	0.0024	0.10	0.10	0.07
C.D. (P=0.05)	0.0074	0.0078	0.0061	0.0093	0.0085	0.0076	0.0077	0.0081	0.0067	0.23	0.25	0.20
Balanced Fertilization												
NPK	0.2582	0.2600	0.2591	0.3187	0.3220	0.3204	0.2800	0.2794	0.2797	6.96	7.22	7.09
NPKS	0.2727	0.2747	0.2737	0.3413	0.3438	0.3426	0.3003	0.3011	0.3007	7.37	7.51	7.44
NPKZn	0.2675	0.2709	0.2692	0.3337	0.3357	0.3347	0.2937	0.2951	0.2944	7.26	7.41	7.33
NPKSZn	0.2857	0.2879	0.2868	0.3557	0.3551	0.3554	0.3092	0.3112	0.3102	7.63	7.71	7.67
SEm ±	0.0036	0.0038	0.0026	0.0045	0.0041	0.0031	0.0037	0.0040	0.0027	0.11	0.12	0.08
C.D. (P=0.05)	0.0086	0.0090	0.0075	0.0107	0.0098	0.0057	0.0088	0.0094	0.0067	0.27	0.29	0.24
Growth Regulators												
Water spray	0.2663	0.2690	0.2677	0.3310	0.3315	0.3313	0.2900	0.2897	0.2899	6.97	7.17	7.07
BA at 10 ppm	0.2751	0.2769	0.2760	0.3432	0.3456	0.3444	0.3015	0.3035	0.3025	7.61	7.75	7.68
NAA at 100 ppm	0.2717	0.2742	0.2730	0.3379	0.3404	0.3392	0.2959	0.2968	0.2964	7.33	7.47	7.40
SEm ±	0.0018	0.0017	0.0012	0.0023	0.0020	0.0015	0.0022	0.0025	0.0017	0.09	0.10	0.06
C.D. (P=0.05)	0.0042	0.0039	0.0035	0.0054	0.0046	0.0043	0.0051	0.0058	0.0047	0.20	0.22	0.18

et al. 1974) and volatile yield by multiplying per cent volatile oil content by seed yield.

RESULTS AND DISCUSSION

Effect of plant density: The results revealed that planting of fennel at a density of 27.77 thousand plants ha⁻¹ produced superior quality seeds that contains 8.52 and 17.83, 11.16 and 25.67 and 11.14 and 23.62 per cent higher total chlorophyll content in seeds at first, second and third plucking, 9.90 and 15.12 per cent higher total soluble sugars over the densities 55.55 and 83.33 thousand

plants ha⁻¹ and the seeds is classified as good to excellent. However, the volatile oil and protein content were not affected due to planting of crop at different densities, significantly.

The seeds produced at lower density were superior due to over all better growth of the individual plants which explore higher inputs. Also, supply of assimilates to the seeds under low population was more which inhibited abscission layer formation and delayed senescence and thus chlorophyll content of seeds was improved.

Table 3. Effect of plant density, fertilization and growth regulators on total soluble sugars and protein content of fennel seed.

Treatment	Total soluble sugars (mg 100 mg ⁻¹)			Protein content (%)		
	2002-03	2003-04	Pooled	2002-03	2003-04	Pooled
Plant Density (*000 ha⁻¹)						
27.77	4.081	4.087	4.084	17.78	17.46	17.62
55.55	3.715	3.716	3.716	17.64	17.32	17.48
83.33	3.544	3.551	3.548	17.55	17.24	17.39
SEm ±	0.025	0.017	0.015	0.07	0.06	0.04
C.D. (P=0.05)	0.060	0.040	0.043	NS	NS	NS
Balanced Fertilization						
NPK	3.698	3.709	3.704	17.46	17.16	17.31
NPKS	3.782	3.784	3.783	17.71	17.41	17.56
NPKZn	3.757	3.760	3.759	17.62	17.32	17.47
NPKSZn	3.883	3.886	3.884	17.83	17.48	17.65
SEm ±	0.029	0.020	0.018	0.08	0.07	0.05
C.D. (P=0.05)	0.069	0.046	0.050	0.20	0.16	0.15
Growth Regulators						
Water spray	3.711	3.719	3.715	17.54	17.23	17.39
BA at 10 ppm	3.788	3.790	3.789	17.76	17.43	17.59
NAA at 100 ppm	3.841	3.845	3.843	17.66	17.36	17.51
SEm ±	0.021	0.015	0.013	0.05	0.05	0.04
C.D. (P=0.05)	0.047	0.035	0.036	0.11	0.12	0.10

NS = Not significant

Effect of fertilization: Application of NPKSZn recorded significantly higher chlorophyll content of seed in all the three plucking of umbels. This treatment also recorded maximum mean visual score (7.67) which was 8.18 per cent higher over the treatment NPKS, however, it was statistically at par with NPKS during both the years. The seeds produced under the influence of NPKSZn had significantly higher total soluble sugar content and recorded maximum (3.884 mg 100mg⁻¹) which was 4.86, 3.33 and 2.67 per cent higher over NPK, NPKZn and NPKS, respectively. Further, application of NPKSZn recorded maximum protein and volatile oil content, was significantly higher over NPK during both the years.

The superiority of seeds produced under the influence of NPKSZn which included N, P, K, S and Zn seems to be due to greater availability of metabolites to seed which facilitate greater conversion of metabolites into volatile oil as well as accumulated total soluble sugar and sustenance of greening in seeds. These results are in concurrence with the finding of Khan *et al.* (1999) and Manure *et al.* (2000).

Effect of plant growth regulators: Application of BA at 10 ppm and NAA at 100 ppm increased the total chlorophyll content of seeds by 3.10 and 1.98 per cent at first plucking, 3.95 and 2.38 per cent at second plucking

Table 4. Effect of plant density, fertilization and growth regulators on volatile oil content of seed and volatile oil yield of fennel.

Treatment	Volatile oil content (%)			Volatile oil yield (kg ha ⁻¹)		
	2002-03	2003-04	Pooled	2002-03	2003-04	Pooled
Plant Density (*000 ha⁻¹)						
27.77	1.515	1.509	1.512	26.86	27.25	27.06
55.55	1.511	1.502	1.506	30.92	32.05	31.48
83.33	1.502	1.497	1.499	28.70	30.39	29.55
SEm ±	0.005	0.008	0.005	0.68	0.55	0.44
C.D. (P=0.05)	NS	NS	NS	1.60	1.31	1.25
Balanced Fertilization						
NPK	1.492	1.460	1.476	24.92	26.49	25.71
NPKS	1.512	1.511	1.512	29.51	30.65	30.08
NPKZn	1.508	1.506	1.507	28.59	29.67	29.13
NPKSZn	1.525	1.533	1.529	32.29	32.79	32.54
SEm ±	0.006	0.010	0.006	0.78	0.64	0.51
C.D. (P=0.05)	0.014	0.023	0.014	1.85	1.51	1.44
Growth Regulators						
Water spray	1.495	1.488	1.491	26.43	27.40	26.92
BA at 10 ppm	1.516	1.507	1.511	29.19	29.92	29.55
NAA at 100 ppm	1.517	1.513	1.515	30.86	32.37	31.62
SEm ±	0.005	0.007	0.004	0.49	0.51	0.35
C.D. (P=0.05)	0.011	0.015	0.012	1.13	1.17	0.99

NS = Non-significant

Table 5. Interaction effect between plant density and fertilization on chlorophyll content of fennel seeds on pooled basis.

Number of Plucking	Plant density ('000 ha ⁻¹)	Fertilization treatment			
		NPK	NPKS	NPKZn	NPKSZn
First	27.77	0.2825	0.2987	0.2877	0.3003
	55.55	0.2470	0.2663	0.2660	0.2994
	83.33	0.2450	0.2532	0.2489	0.2573
Second	27.77	0.3643	0.3845	0.3705	0.3864
	55.55	0.3039	0.3436	0.3386	0.3689
	83.33	0.2929	0.2996	0.2949	0.3109
Third	27.77	0.3164	0.3346	0.3226	0.3388
	55.55	0.2628	0.3011	0.2977	0.3193
	83.33	0.2612	0.2664	0.2628	0.2712
Plucking	SEm ±	C.D. (P=0.05)			
First	0.0045	0.0150			
Second	0.0053	0.0151			
Third	0.0047	0.0134			

and 4.35 and 2.24 per cent at third plucking of umbels, respectively over water spray. It was observed that the seed produced under the influence of BA at 10 ppm were significantly superior in respect to appearance over NAA at 100 ppm and water spray. Further, application of NAA at 100 ppm and BA at 10 ppm recorded significantly higher total soluble sugar, protein and volatile oil content in seeds over water spray.

The improvement in quality of fennel seeds as a result of growth regulators could be attributed to their pivotal role in creating congenial nutritional environment for greater availability of essential nutrients and regular supply of metabolites for protein synthesis through improved translocation of metabolites from source to sink. The significant effect of NAA on quality of seeds were due to increased chlorophyll content, nitrate reductase activity and uptake of nitrogen by seed, enhanced RNA synthesis and inhibitory effect on growth inhibition substances.

Application of BA, increased total chlorophyll and protein content of seeds seems to be due to increased

nitrate reductase activity which lead to nitrogen uptake, a basic element required for both of these two. Further, BA a cytokinin may stimulate protein synthesis by stimulating the recruitment of untranslated RNA into polysomes. These results are in accordance with Pandey *et al.* (2001) and Singh (2004).

Interaction effect between plant densities and fertilization: The results revealed that with increase in plant densities from 27.77 to 83.33 thousand plants ha⁻¹ significantly decreased chlorophyll content of seeds. Further, with increase in fertilizer levels, the chlorophyll content of seeds increased significantly (Table 5). However, when plant density increased with increasing fertilizer levels the decrease in chlorophyll content was less.

REFERENCES

- A.O.A.C. (1960). Official Methods of Analysis, 9th Ed. Association of Agricultural Chemist, Washington, D.C.
- Hodge, J.E. and Hofreiter, B.T. (1962). In: N. Histlr and B.E. Miller (eds.) Methods in Carbohydrate Chemistry. Academic Press, New York.

- Khan, M.M.A., Azam, Z.M. and Samiullah (1999). Changes in the essential oil constituents of fennel (*Foeniculum vulgare* Mill) as influenced by soil and foliar levels of N and P. *Can. J. Plant Sci.* **79**: 587-591.
- Manure, G.R., Shivaraj, B., Farooqi, A.A. and Surendra, H.S. (2000). Yield attributes, seed yield, essential oil yield and oil content of coriander (*Coriandrum sativum* L.) as influenced by the graded levels of nitrogen, sulphur and zinc nutrition in red sandy loam soils. Conf. on Spices and Aromatic Plants : Challenges and Opportunities in the New Century. 20-23 Sept., 2000, pp. 139-144. Calicut, Kerala, India.
- Moran, R. and Porath, D. (1980). Chlorophyll determination in intact tissues using N, N- dimethyl formamide. *Plant Physiol.* **65**: 478-479.
- Pandey, D.M., Goswami, C.L. and Kumar, B. (2001). Effect of plant growth regulators on photosynthesis in cotton (*Gossypium hirsutum* L.) under water logging. *Indian J. Plant Physiol.* **6**: 90-94.
- Singh, A.K. (2004). Hi-Tech Horticulture. Plant bioregulators. Agrotech Publishing Academy, Udaipur.
- Tiwari, P.N. (1974). Pulsed NMR for rapid and non destructive determination of oil in oil seed. *J. Oil Chem. Sci.* **51**: 1049.