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ORIGINAL ARTICLES

Effect of different levels of planting distances, irrigation and fertigation on quality characters of main & ratoon banana crop cv.Grand Naine

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ABSTRACT

A field experiment was conducted to evaluate the effect of different levels of planting distances, irrigation and fertigation levels on quality characters of the main & ratoon banana crops cv. Grand Naine (Musa AAA). Main and ratoon crops grown at the widest planting distance 1.75 x 1.75 m showed significantly better fruit quality characters. Application of irrigation at a rate of 764.30 mm per year during main crop substantially improved fruit quality characters. In the ratoon crop, irrigation at a rate of 1187.10 mm per year was observed to be most economical and effective in getting the best fruit quality.In the both main and ratoon crops, 80 per cent of the recommended fertigation dose (160 N:32 P :192 K g per plant per year) performed well in respect of fruit quality characters. Hence, fertigation with 80 per cent of the recommended dose was found to be optimum and economical. Main and ratoon crops grown under different treatment combinations (using drip and fertigation system) were superior to the crop grown under the control treatment (using surface irrigation and conventional application of solid fertilizers) as regards to most fruit quality parameters. The treatment combination D_1 x I_1 x F_3 in the main crop improved most of the fruit quality characters. The treatment combination D_1 x I_2 x F_3 maintained medium level of ratoon crop fruit quality characters.

Key words: Banana, Fertigation, Irrigation, Planting distances, quality character

Introduction

Banana is the cheapest fruit and rich source of energy in the form of sugar and starch. It contains almost all essential nutrients of which most of them are used in several medicines. The major hurdle in quality banana production is the lack of professional outlook towards its production and mismanagement of the available natural resources. planting distances, irrigation and fertigation are the most important constraints which significantly influence the yield quality (Morton, 1987). Abruna *et al*. (1980) found reduction in fruit total soluble solids, total sugars, acidity and sugar/acidity ratio in fruits, when irrigation was given in high amount at frequent intervals. Teaotia *et al*. (1972) reported that irrigation level at 2.5 ha cm achieved higher total sugar in fruits than 7.5 ha cm. Irrigation level at 60 per cent depletion of ASM increased significantly total sugar fruits than 209 per cent depletion of ASM (Krishnan and Shanmugavelu, 1979). Banana cv. Basrai were irrigated by furrows or by drip irrigation. Fruit TSS and total yellow pigments contents were lowest and total chlorophyll and vitamin C (ascorbic acid) contents were highest in furrow method of irrigation at 75 mm CPE or by drip irrigation at the 60 per cent wetting area level, indicating that these treatments could retard ripening and extend post harvest life (Patel *et al*., 1993).

Materials And Methods

The experiment was conducted during 2003-2005 at Precision Farming Development Centre, Dr. Annasaheb Shinde College of Agricultural Engineering, Mahatma Phule Krishi Vidyapeeth, Rahuri, India. The experiment was laid out in split-split plot design, with 27 treatment combinations besides control (Table 2), replicated thrice with three plants in each replication. Guard rows were provided on all sides of the plots.

Treatment details:

I) Main factors : 3 levels of planting distances (D):

D_1	1.75 x 1.75 m	(3265 plants/ha)
D_2	1.5 x 1.5 m	(4444 plants/ha)
D_3	1.25 x 1.25 m	(6400 plants/ha)

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II) Sub factors : 3 levels of irrigation through drip (I):

I_1 0.4 PE
I_2 0.6 PE
I_3 0.8 PE

III) Sub-sub factors :3 levels of (Water soluble NPK fertilizers through drip (F):

F_1 120 % RD (240 N : 48 P : 288 K g/plant/year)
F_2 100 % RD (200 N : 40 P : 240 K g/plant/year)
F_3 80 % RD (160 N : 32 P : 192 K g/plant/year)

iv) Control : 1.5 x 1.5 m planting distance (4444 plants/ha) , *surface irrigation with application of recommended fertilizers dose (RD)in solid form.*

The soil of the experimental plots was prepared to a fine tilth by cross wise ploughing followed by harrowing with disk harrow. Field was made free from organic residues of the previous crop or weed .Furrow then irrigated and farm yard manure (FYM) 10 kg was mixed for each hill .Tissue cultured plants of banana cv. Grand Naine were used as planting material. Banana planting was done on 31 July, 2003 and there after recommended package of cultural practices were followed. The special horticulture practices viz., earthing up, desuckering, propping removal of floral buds etc. were carried out as usual. Drip and surface irrigation was scheduled on the basis of pan evaporation (PE) .The time of operation of drip irrigation system was decided by knowing the average discharge of microtube per plant.

Two types of fertilizers i.e., normal solid fertilizers and water soluble fertilizers were used .The recommended fertilizer dose(R F D) of solid fertilizers (200N: 40 P2O5 : 240 K2O g per plant per year) was applied for control treatment by ring method .Out of 25 per cent N through organic fertilizers (10 kg FYM at the time of planting and 75 per cent through inorganic fertilizers in four equal split doses at 45,90 and 210 days after planting .Phosphorus 40 g per plant was applied at the time of planting and 240 g K2O was applied in four equal split doses at the time of planting 165, 255 and 300 days after planting .Fertilizers for the treatment combinations were applied through drip irrigation system (fertigation).Weighed quantity of water soluble fertilizers and urea was added in water and injected in the lateral line as per treatments. Application of water soluble fertilizer through drip irrigation system was scheduled at monthly intervals spread over a period of 10 months, starting from one month after setting of suckers. The following fertilizers grades were used during experimentation (Table1).

The representative fingers were allowed for natural and uniform ripening were utilized to determine the various quality characters of fruit. The total soluble solid was determined by using Erma hand refractometer (AOAC, 1960) and expressed in percentage.Titrable acidity was determined by titrating a known quantity of blended sample diluted with water against standard sodium hydroxide solution, using phenolphthalein as an indicator and was expressed as citric acid in percentage (A.O.A.C., 1960).The total and reducing sugars were determined by method advocated by Ranganna (1978). Non-reducing sugars were calculated as the difference between total and reducing sugars. The values were expressed in percentage.

Results And Discusion

In any production system, the primary objective is to obtain maximum fruit yield per unit without affecting the fruit quality. The fruit quality in banana is mainly judged by sugar content and acidity in the pulp.

The data revealed that there was a significant difference in fruit quality due to treatments. Significantly greater values of TSS, TSS/acidity ratio, reducing sugar and total sugars were observed with the closest planting distance treatment (1.25 x 1.25 m) in main and ratoon crops. This result might be due to less amount of water was received by each plant because of high competition under more plant population and limited water supply. Non-reducing sugars and acidity in banana fruits was not apparently influenced by different levels of spacing or by irrigation levels or by fertigation levels. The result also revealed that irrigation level I_1 40% PE (764.26 mm per year) tended to improve fruit quality characters of main crop. I_2 60% PE (1186.99 mm per year) irrigation level in ratoon crop recorded maximum reducing sugar, less acidity and higher TSS content in fruit pulp. The increase in TSS might be due to accumulation of sugar and other soluble component from hydrolysis of protein and oxidation of ascorbic acid.These observations are in conformity with those of Mahalakshmi (2000) who found that lower irrigation water with optimum level of nutrient was beneficial for increasing the quality in banana. Furthermore, Gates (1968) also reported that under conditions of limited water, the starch hydrolysis was higher resulting in higher total sugar.

This result also clearly showed that the widest planting distance D_1 (1.75 x 1.75 m) maintain the second class in respect of all quality characters during main and ratoon crops. Markedly increased total sguar content of

banana fruits may be due to more accumulation of photosynthates because higher nitrogen levels increased pseudostem height, girth, leaf number and leaf area and also helped in better availability of nutrients during crop period, which also helps in accumulation of photosynthates. Ultimately favourable effects were directly helpful in increasing the total sugar content. The markedly increase in TSS/acid ration may be de to an increase in TSS content at ripening stage of banana fruit. Ratoon crop grown under normal planting distance in treatment combination recorded more total sugar (15.56%), reducing sugar (12.55%) and TSS (20.16%) in relation to control. The results are supported by the findings of Cevik *et al*. (1985).

In the present study, higher reducing sugar, total sugar, TSS, TSS : acidity and lesser acidity per cent were found to be associated with F_3 (80% of the recommended dose) fertigation level, in main crop . This result proved that F_3 fertigation level provided the exact amounts of nitrogen and potassium nutrients which might have resulted in improving quality characters. Martin Prevel (1973) opined that excess K application as compared to nitrogen reduced the fruit quality. Hassan *et al*. (1999) attributed increased TSS and total sugar to the effect of optimum potash dose.

In the present experiment, all treatment combinations were found to be superior over control treatment. Similar results were also reported by Cevik *et al*. (1985) who stated that in drip irrigated plants, the TSS content of fruits was higher as compared to surface irrigated plants.

From these experimental results, it appears that the combination D_1 x I_1 x F_3 and D_2 x I_2 x F_2 in main and ratoon crop, respectively, showed increase in quality characters in respect of total sugar (1.10 and 0.36%), reducing sugar (2.30 and 1.40%), TSS (3.10 and 1.50%) and acidity (0.10 and 0.03%) as compared to control treatment (Table 2, 3). The results are in conformity with Mahalakshmi *et al*. (2001).

Table 1: Fertilizers grades used during experimentation

Fertilizer grade	Type of Fertilizer	Nutrient levels N:P:K	Purpose
Urea NH2_CO_NH2	N S F	46 : 0 :0	For full nitrogen requirement
Single superphosphate P2O5	N S F	0 : 16 : 0	For full phosphorus
Muriate of potash KCl	N S F	0 : 0 : 60	For full potassium requirement
NPK	W S F	19 : 19 : 19	For full P and part of N and K requirement
Urea	W S F	46 : 0 : 0	To cater remaining N left out.
K	W S F	0 : 0 : 50	To cater remaining K left out.

WSF,Water-soluble fertilizer NSF,Normal solid fertilizer

Table 2: Interaction effects of planting distances, irrigation and fertigation levels (D x I x F) on fruit quality characters of main banana crop.

Treatments	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Acidity (%)	T.S.S (%)	T.S.S : acidity ratio
Planting distances, irrigation and fertigation levels interactions (D x I x F)						
D_1 x I_1 x F_1	12.93^{hij}	2.74^{defgh}	15.82^{efgh}	0.286^{cde}	20.75^{o}	72.59^{kl}
D_1 x I_1 x F_2	13.16^{ghi}	2.63^{efghi}	15.92^{defgh}	0.283^{de}	20.95^{m}	73.85^{k}
D_1 x I_1 x F_3	13.64^{ef}	2.43^{fghijk}	16.20^{abcdef}	0.260^{h}	21.65^{h}	83.20^{g}
D_1 x I_2 x F_1	14.16^{cd}	2.07^{hijk}	16.34^{abcde}	0.240^{j}	22.45^{e}	92.31^{d}
D_1 x I_2 x F_2	12.61^{jkl}	2.96^{cdef}	15.72^{fgh}	0.293^{bc}	20.15^{q}	67.95^{m}
D_1 x I_2 x F_3	13.39^{fg}	2.37^{fghijk}	15.89^{efgh}	0.286^{cde}	20.85^{n}	72.42^{kl}
D_1 x I_3 x F_1	14.29^{bc}	2.05^{ijk}	16.45^{abcd}	0.236^{jk}	22.55^{d}	95.27^{c}
D_1 x I_3 x F_2	11.45^{o}	3.84^{a}	15.50^{gh}	0.313^{a}	18.85^{v}	59.71^{q}
D_1 x I_3 x F_3	13.28^{fgh}	2.57^{efghij}	15.99^{cdefgh}	0.270^{g}	21.25^{k}	79.08^{hi}
D_2 x I_1 x F_1	12.50^{klm}	2.21^{ghijk}	14.84^{i}	0.310^{a}	19.85^{s}	63.74^{no}
D_2 x I_1 x F_2	13.28^{fgh}	2.61^{efghi}	16.03^{cdefg}	0.270^{g}	21.25^{k}	79.08^{hi}
D_2 x I_1 x F_3	13.16^{ghi}	2.63^{efghi}	15.92^{defgh}	0.273^{fg}	21.05^{l}	77.71^{ij}
D_2 x I_2 x F_1	12.20^{m}	3.31^{abcd}	15.69^{fgh}	0.306^{a}	19.85^{s}	65.07^{n}
D_2 x I_2 x F_2	13.39^{fg}	$2.50^{efghijk}$	16.03^{cdefg}	0.266^{gh}	21.35^{j}	80.07^{h}
D_2 x I_2 x F_3	12.40^{lm}	3.15^{bcde}	15.72^{fgh}	0.296^{b}	20.05^{r}	67.14^{m}

Table 2: (Contd…)

Treatments	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Acidity (%)	T.S.S (%)	T.S.S : acidity ratio
D_2 x I_3 x F_1	11.81^{n}	3.53^{abc}	15.53^{gh}	0.311^{a}	19.45^{t}	62.88^{op}
D_2 x I_3 x F_2	12.71^{jkl}	2.95^{cdef}	15.82^{efgh}	0.286^{cde}	20.45^{p}	71.03^{l}
D_2 x I_3 x F_3	12.83^{ijk}	2.78^{defg}	15.75^{fgh}	0.290^{bcd}	20.15^{q}	68.44^{m}
D_3 x I_1 x F_1	14.43^{abc}	1.99^{ijk}	16.52^{abc}	0.236^{jk}	22.75^{c}	96.96^{c}
D_3 x I_1 x F_2	13.28^{fgh}	$2.51^{efghijk}$	15.92^{defgh}	0.280^{ef}	21.05^{l}	76.49^{j}
D_3 x I_1 x F_3	14.71^{a}	1.86^{k}	16.67^{a}	0.223^{l}	23.05^{a}	101.90^{a}
D_3 x I_2 x F_1	14.57^{ab}	1.92^{ijk}	16.60^{ab}	0.230^{kl}	22.93^{b}	99.66^{b}
D_3 x I_2 x F_2	11.63^{no}	3.64^{ab}	15.46^{h}	0.310^{a}	19.05^{v}	61.17^{pq}
D_3 x I_2 x F_3	14.43^{abc}	1.99^{ijk}	16.52^{abc}	0.236^{jk}	22.75^{c}	96.96^{c}

D_3 x I_3 x F_1	13.89^{de}	2.33^{fghij}	16.34^{abcde}	0.250^{i}	22.05^{f}	88.34^{e}
D_3 x I_3 x F_2	13.64^{ef}	2.36^{fghij}	16.13^{bcdef}	0.260^{h}	21.55^{i}	82.13^{g}
D_3 x I_3 x F_3	13.89^{de}	2.23^{ghij}	16.23^{abcdef}	0.260^{h}	21.85^{g}	85.35^{f}
Control	11.36	3.59	15.15	0.32	18.56	56.88
SE ±	0.11	0.19	0.15	0.032	0.03	0.61
CD (0.05)	0.33	0.55	0.45	0.009	0.09	1.75
CV%	15.30	12.97	17.20	18.70	15.030	13.50

In each column means followed by different letters are significantly different at the 5% level using Duncan's Multiple Test.

Table 3: Interaction effects of planting distances, irrigation and fertigation levels (D x I x F) on fruit quality characters of ratoon banana crop.

Treatments	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Acidity (%)	T.S.S (%)	T.S.S : acidity ratio
Planting distances, irrigation and Fertigation levels interactions (D x I x F)						
D_1 x I_1 x F_1	12.40^{ef}	2.97^{a}	15.53^{cde}	0.296^{bc}	20.00^{fg}	66.97^{ghi}
D_1 x I_1 x F_2	12.51^{ef}	2.87^{abc}	15.53^{cde}	0.296^{bc}	20.20^{efg}	68.26^{fgh}
D_1 x I_1 x F_3	13.89^{bc}	2.13^{de}	16.13^{b}	0.266^{fg}	21.67^{bcd}	81.95^{d}
D_1 x I_2 x F_1	13.64^{c}	2.23^{cde}	15.99^{b}	0.260^{gh}	21.47^{cd}	81.81^{d}
D_1 x I_2 x F_2	12.40^{ef}	2.97^{a}	15.53^{cde}	0.296^{bc}	20.00^{fg}	66.97^{ghi}
D_1 x I_2 x F_3	13.28^{cd}	2.32^{bcde}	15.72^{c}	0.280^{de}	21.00^{de}	76.31^{e}
D_1 x I_3 x F_1	13.89^{bc}	2.09^{de}	16.10^{b}	0.243^{ij}	22.13^{abc}	91.06^{bc}
D_1 x I_3 x F_2	12.40^{ef}	2.97^{a}	15.53^{cde}	0.296^{bc}	20.00^{fg}	66.97^{ghi}
D_1 x I_3 x F_3	11.92^{f}	3.30^{a}	15.41^{de}	0.308^{ab}	19.45^{g}	63.41^{i}
D_2 x I_1 x F_1	12.42^{ef}	2.98^{a}	15.56^{cde}	0.293^{bc}	19.80^{fg}	66.77^{ghi}
D_2 x I_1 x F_2	12.83^{de}	2.69^{abcd}	15.66^{cd}	0.286^{cd}	20.50^{ef}	71.77^{f}
D_2 x I_1 x F_3	12.41^{ef}	2.93^{ab}	15.50^{cde}	0.296^{bc}	20.00^{fg}	67.42^{fghi}
D_2 x I_2 x F_1	12.51^{ef}	2.90^{ab}	15.56^{cde}	0.293^{bc}	20.17^{efg}	68.51^{fg}
D_2 x I_2 x F_2	13.28^{cd}	2.32^{bcde}	15.72^{c}	0.280^{de}	21.00^{de}	76.31^{e}
D_2 x I_2 x F_3	13.30^{cd}	2.30^{bcde}	15.72^{c}	0.276^{def}	21.00^{de}	76.35^{e}
D_2 x I_3 x F_1	11.90^{f}	3.29^{a}	15.36^{e}	0.310^{a}	19.50^{g}	63.48^{i}

Table 3: (Contd…)

Treatments	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Acidity (%)	T.S.S (%)	T.S.S : acidity ratio
D_2 x I_3 x F_2	12.20^{ef}	3.14^{a}	15.50^{cde}	0.296^{bc}	20.00^{fg}	67.48^{fghi}
D_2 x I_3 x F_3	12.10^{f}	3.13^{a}	15.40^{de}	0.304^{ab}	19.47^{g}	63.39^{i}
D_3 x I_1 x F_1	14.71^{a}	1.68^{e}	16.49^{a}	0.220^{k}	23.00^{a}	102.70^{a}
D_3 x I_1 x F_2	13.90^{bc}	2.12^{de}	16.13^{b}	0.250^{hi}	22.00^{bc}	88.19^{c}
D_3 x I_1 x F_3	14.44^{ab}	1.96^{e}	16.50^{a}	0.223^{k}	23.02^{a}	102.7^{a}
D_3 x I_2 x F_1	13.90^{bc}	2.12^{de}	16.13^{b}	0.250^{hi}	22.00^{bc}	88.14^{c}
D_3 x I_2 x F_2	11.91^{f}	3.28^{a}	15.37^{e}	0.306^{ab}	19.51^{g}	63.57^{hi}
D_3 x I_2 x F_3	14.30^{ab}	1.84^{e}	16.23^{b}	0.236^{j}	22.50^{ab}	95.08^{b}
D_3 x I_3 X F_1	13.28^{cd}	2.32^{bcde}	15.72^{c}	0.276^{def}	21.00^{de}	76.31^{e}
D_3 x I_3 x F_2	13.29^{cd}	2.31^{bcde}	15.72^{c}	0.270^{efg}	21.00^{de}	78.34^{de}
D_3 x I_3 x F_3	13.89^{bc}	2.13^{de}	16.13^{b}	0.250^{hi}	22.00^{bc}	88.40^{c}
Control	11.90	3.29	15.36	0.307	19.50	63.47
SE ±	0.19	0.19	0.08	0.042	0.29	1.42
CD (0.05)	0.55	0.55	0.23	0.001	0.84	4.08
CV%	12.55	12.98	16.90	12.63	12.43	13.22

In each column means followed by different letters are significantly different at the 5% level using Duncan's Multiple Test.

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