Global Journal of Plant Ecophysiology, 3(2): 104-109, 2013
ISSN 2074-0891
This is a refereed journal and all articles are professionally screened and reviewed

# ORIGINAL ARTICLES

## Effect of different levels of planting distances, irrigation and fertigation on growth 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 growth characters of the banana main crops cv. Grand Naine (Musa AAA). Main and ratoon crops grown at the widest planting distance 1.75 × 1.75 m showed significantly better growth and shortened the total crop duration. Application of irrigation at a rate of 764.30 mm per year during main crops substantially improved growth and shortened crop duration. In the ratoon crops, irrigation at a rate of 1187.10 mm per year was observed to be most economical and effective in decreasing number of days to shooting that subsequently reduced the total crop duration. 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 growth parameters and shortened the total crop duration. Hence, fertigation with 80 per cent of the recommended dose was found to be optimum and economical. Main and ratoon crops grown at $D_1 \times I_1 \times F_3$ and $D_1 \times I_2 \times F_3$, respectively were superior to the control treatment in terms of growth parameters and total crop duration, and were found to be optimum and viable options to adopt for the respective crops in order to avoid unnecessary extra nutrient uptake that might increase the vegetative growth and extended the total crop duration. 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 growth parameters. Besides plants grown with the different treatment combinations required less number of days to complete the total crop duration than those grown under control treatment. The treatment combination $D_1 \times I_1 \times F_3$ in the main crop improved most of the growth characters and shortened the total crop duration. The treatment combination $D_1 \times I_2 \times F_3$ in the ratoon crop trail was found to be superior in respect of growth characters. It also and required less number of days to complete the total crop duration. However, the total crop duration of the ratoon was extended nearly by one month more as compared to the main crops.

***Key words:*** Banana, Fertigation, Irrigation, Planting distances, Growth character

### Introduction

Banana plant population per unit area depends on various considerations such as cultivar topography, soil fertility and desuckering. The increase in pseudostem height or reduction in pseudostem girth under high density planting is a normal phenomenon (Ahmed and Mannan 1970; Chattopadhyay *et al.*1980; Reddy1982; Anonymous 1989) Reduction in individual bunch weight than normal at high density planting than normal planting, and slight reduction in quality parameters has been observed by some research workers (Apshara 1997; Nalina 2000; Mahlakshmi, 2000). The banana crop is a large herbaceous plant. As such; it has a very high demand for water (Simmonds, 1966). Arscott *et al.* 1965 reported that water deficits occurring during the growth phase affect the rate of leaf production .Holders and Gumbs 1983 found that increased soil moister stress after bunch emergence significantly decreased leaf number. Crop duration in *cv. Robusta* was delay at very high and very low evaporation replenishment (Hegde and Srinivas, 1990). According to Simmonds 1959, the significance of regular water supply in increasing the yield of banana has long been recognized. Banana is a surface feeder and a nutrient exhaustive crop; hence optimum quantities of major nutrients are necessary for proper growth and high yield.

### 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

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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) |

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). Nine plants were selected randomly in each treatment for recording the growth characters. Observations on growth characters were recorded at shooting (flowering) stage. Height of the pseudostem was measured at shooting from the base of the trunk to the axil of the youngest leaf and expressed in centimeters .The girth of pseudostem was measured at 30 cm height from the ground level and expressed in centimeters. The number of leaves present at the time of shooting were counted and recorded. Length of lamina was measured from the base to it's apex along with midrib and width at the broadest portion of the lamina. The product of length and breadth was multiplied by the factor 0.8 (Murray, 1960) and leaf area was expressed in $m^2$. The number of suckers per plant up to shooting and at harvest were counted and recorded. Days required from planting of main crop for flowering (shooting) and further till harvesting (maturity) were recorded. Total crop duration was computed on this basis.

**Results And Discusion**

The planting distances of banana varies a great deal, and it depends on the variety grown, crop duration, growth habit and method of cultivation.

Pseudostem height recorded at shooting stage showed that, all the treatments differed significantly from control. The treatment having narrow planting distances (1.25 × 1.25 m) invariably registered more plant height

irrespective of the treatment combinations in both main and ratoon banana crop. The increase in pseudostem height under narrow planting distances is a normal phenomenon (Ahmed and Mannan, 1970; Nalina *et al*., 2000) which is primarily due to the mutual shading of plants resulting in competitive growth rate to intercept the light (Murry, 1960; Reddy, 1982). Similarly when compared to control, all planting distances treatment registered increase in pseudostem girth in main crop.

In main crop, maximum number of functional leaves, leaf area and suckers per plant were maintained at the widest planting distance of 1.75 × 1.75 m. On the other hand, in ratoon crop, more pseudostem height and girth and number of functional leaves per plant were found at normal planting distance of 1.50 × 1.50 m (Table 2). These results are in conformity with the observations of Athani and Hulamani (2001). Sufficient numbers of functional leaves harnessed the light energy and synthesize adequate photosynthates for biomass production. More number of functional leaves produced from banana is an indication of its vigour, reflecting on yield and quality of fruit as they act as the source for the developing bunches.

Growth response of banana to NPK fertilization through drip irrigation (fertigation) indicated that $F_3$ level (80% RDF) induced better growth in main crop under study. This result is almost in par with the data previously reported by Sylvio Belalcazar and Jose Espinosa (2000). Normally, higher fertigation and irrigation levels caused excess vegetative growth that may cause delay in flowering period (Viers, 1972).

The growth observation of main crop recorded on functional leaves, leaf area and number of suckers per plant at shooting stage indicated that $D_1 \times I_1 \times F_3$ treatment combination produced more vigorous plants (Table 2) , and the same was in ratoon crop at $D_2 \times I_2 \times F_2$ treatment combination (Table 3).

The overall assessment of various fertigation treatment on growth characters revealed that the widest planting distance $D_1$ (1.75 × 1.75 m) with $I_1$ irrigation level (764.26 mm per year) and $F_3$ fertigation level (80% RDF) in main crop resulted in favourable growth and higher yield. In ratoon crop the normal planting distance $D_2$ (1.50 × 1.50 m) with $I_2$ irrigation level (1186.99 mm per year) and $F_2$ fertigation level (100% RDF) were very effective in building up strong vegetative foundation, healthy enough for efficiency physiological activities which resulted in better growth and increase yield with 67% against control.

The result of this experiment revealed that main and ratoon crop grown under treatment combination (using drip and fertigation system) were superior in respect of growth characters as compared to the crop grown under control treatment (using surface irrigation system with conventional application of solid fertilizers). This finding falls in line with the results reported by Cevik *et al*. (1985) who opined that growth of the banana plant was superior under drip irrigation than surface irrigation. This view has been shared by Hegde and Srinivas (1991).

The importance of leaf area on growth has been documented in many crops. An increase in leaf area results in better utilization of solar energy. In the present study, leaf area was high under drip and fertigation treatment combination as compared to control treatment. These results proved that the application of drip irrigation and fertigation system were able to produce higher leaf area, depicting better utilization of land area and solar energy.

Crop duration or crop cycle interval is an important factor to be considered in banana especially under HDP; as evidence show that extension of crop duration normally encounted under HDP system. In the present experiment, it was revealed that widest planting distance caused reduction in crop duration of main and ratoon (Table 4 ). This might be due to higher light penetration per leaf, high microclimate temperature due to less shade by leaves borned in these plants as viewed by Apshara, (1997), Nalina (2000) and Mahalakshmi (2000). Belatcazar *et al*. (1994) was opined that extended duration under HDP could be compensated by higher yield per unit area, so that farmer could afford to wait for extra three to four months which decreased land use efficiency.

From these experimental results, it appears that the main crop grown under $D_1 \times I_1 \times F_3$ combination gave early shooting by 66 days less than control , while the combination $D_2 \times I_2 \times F_2$ tended to decrease total duration of ratoon crop by 55 day less than control (table 4). This is in agreement with Athani and Hulamani (2001) who found that the crop grown under wide spacing required less number of days to shooting (226) and total crop duration (338). Mahalakshmi (2000) also noted early shooting, early bunch development including total crop duration under low levels of nutrients and water. Higher water might have triggered the active growth, extending the duration especially in the presence of higher nutrient availability. Hazarika and Mohan (1991) found that increase N levels resulted in increasing vegetative growth. The data in (Table 4) indicated that in ratoon crop shooting and harvest of bunches was delayed by one month than that of main crop. Shading from the canopy of main crop might be the reason for the low growth of ratoon suckers that subsequently extended ratoon crop duration.

From the (Table 4) it is revealed that main and ratoon crops grown under control treatment recorded delay in shooting and harvest of bunches as compared to drip and fertigation treatments. The results are in agreement with Hegde and Srinivas (1990) who reported that banana plants under drip irrigation flowered earlier than those under surface irrigation system.

**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:** Influence of planting distance, irrigation and fertigation levels interactions on growth characters at shooting of main crop

| Treatment | Pseudostem height (cm) | Pseudostem girth (cm) | Number of functional leaves | Leaf area (m²) | Number of suckers/ plant |
|---|---|---|---|---|---|
| Planting distances, irrigation and fertigation levels interactions (A x B x C) | | | | | |
| $D_1$ x $I_1$ x $F_1$ | 178.60$^{j}$ | 62.67$^{n}$ | 12.22$^{cdef}$ | 1.22$^{hi}$ | 5.77$^{abcd}$ |
| $D_1$ x $I_1$ x $F_2$ | 189.40$^{hij}$ | 66.00$^{klm}$ | 11.55$^{efgh}$ | 1.34$^{bcdefghi}$ | 5.66$^{abcd}$ |
| $D_1$ x $I_1$ x $F_3$ | 189.40$^{hij}$ | 66.11$^{jklm}$ | 14.11$^{b}$ | 1.35$^{abcdefgh}$ | 5.78$^{abcd}$ |
| $D_1$ x $I_2$ x $F_1$ | 191.10$^{hi}$ | 67.11$^{ghijk}$ | 13.22$^{bcd}$ | 1.36$^{abcdefg}$ | 5.44$^{abcde}$ |
| $D_1$ x $I_2$ x $F_2$ | 189.80$^{hij}$ | 63.89$^{mn}$ | 13.44$^{bc}$ | 1.24$^{ghi}$ | 6.11$^{ab}$ |
| $D_1$ x $I_2$ x $F_3$ | 187.10$^{ij}$ | 64.44$^{lmn}$ | 12.00$^{def}$ | 1.22$^{i}$ | 5.99$^{abc}$ |
| $D_1$ x $I_3$ x $F_1$ | 196.80$^{ghi}$ | 68.67$^{efghi}$ | 11.56$^{efgh}$ | 1.25$^{fghi}$ | 5.44$^{abcde}$ |
| $D_1$ x $I_3$ x $F_2$ | 189.10$^{hij}$ | 66.22$^{jklmf}$ | 12.22$^{cdef}$ | 1.35$^{abcdefg}$ | 5.22$^{abcde}$ |
| $D_1$ x $I_3$ x $F_3$ | 188.00$^{hij}$ | 64.00$^{mn}$ | 12.11$^{cdef}$ | 1.28$^{efghi}$ | 6.33$^{a}$ |
| $D_2$ x $I_1$ x $F_1$ | 194.30$^{hi}$ | 66.67$^{hijkl}$ | 13.22$^{bcd}$ | 1.34$^{abcdefghi}$ | 5.00$^{abcde}$ |
| $D_2$ x $I_1$ x $F_2$ | 224.00$^{cd}$ | 68.67$^{efghi}$ | 11.56$^{efgh}$ | 1.30$^{defghi}$ | 6.11$^{ab}$ |
| $D_2$ x $I_1$ x $F_3$ | 207.30$^{efg}$ | 66.56$^{ijkl}$ | 11.78$^{efg}$ | 1.47$^{a}$ | 5.77$^{abcd}$ |
| $D_2$ x $I_2$ x $F_1$ | 199.20$^{fgh}$ | 67.45$^{ghijk}$ | 11.78$^{efg}$ | 1.39$^{abcdeg}$ | 5.89$^{abc}$ |
| $D_2$ x $I_2$ x $F_2$ | 210.80$^{e}$ | 69.89$^{bcdef}$ | 15.56$^{a}$ | 1.35$^{abcdefg}$ | 4.00$^{de}$ |
| $D_2$ x $I_2$ x $F_3$ | 208.00$^{ef}$ | 70.33$^{bcde}$ | 11.22$^{fgh}$ | 1.45$^{abc}$ | 4.55$^{abcde}$ |

**Table 2:** contd….

| Treatment | Pseudostem height (cm) | Pseudostem girth (cm) | Number of functional leaves | Leaf area (m²) | Number of suckers/ plant |
|---|---|---|---|---|---|
| Planting distances, irrigation and fertigation levels interactions (A x B x C) | | | | | |
| $D_2$ x $I_3$ x $F_1$ | 205.30$^{efg}$ | 67.67$^{fghijk}$ | 11.22$^{fgh}$ | 1.40$^{abcde}$ | 5.00$^{abcde}$ |
| $D_2$ x $I_3$ x $F_2$ | 208.20$^{ef}$ | 69.11$^{defg}$ | 12.67$^{cde}$ | 1.46$^{ab}$ | 5.33$^{abcde}$ |
| $D_2$ x $I_3$ x $F_3$ | 211.00$^{e}$ | 67.22$^{ghijk}$ | 11.22$^{fgh}$ | 1.41$^{abcd}$ | 5.77$^{abcd}$ |
| $D_3$ x $I_1$ x $F_1$ | 210.40$^{ef}$ | 68.45$^{efghij}$ | 12.66$^{cde}$ | 1.39$^{abcde}$ | 3.77$^{e}$ |
| $D_3$ x $I_1$ x $F_2$ | 230.00$^{bcd}$ | 71.33$^{abcd}$ | 11.55$^{efgh}$ | 1.42$^{abcd}$ | 5.44$^{abcde}$ |
| $D_3$ x $I_1$ x $F_3$ | 237.20$^{ab}$ | 69.22$^{cdefg}$ | 10.89$^{fgh}$ | 1.33$^{cdefghi}$ | 4.33$^{bcde}$ |
| $D_3$ x $I_2$ x $F_1$ | 230.60$^{abcd}$ | 72.11$^{ab}$ | 11.00$^{fgh}$ | 1.42$^{abcd}$ | 4.00$^{de}$ |
| $D_3$ x $I_2$ x $F_2$ | 241.10$^{a}$ | 70.67$^{bcde}$ | 10.33$^{hi}$ | 1.36$^{abcdef}$ | 4.77$^{abcde}$ |
| $D_3$ x $I_2$ x $F_3$ | 229.60$^{bcd}$ | 71.56$^{abc}$ | 10.56$^{ghi}$ | 1.38$^{abcde}$ | 4.66$^{abcde}$ |
| $D_3$ x $I_3$ x $F_1$ | 234.60$^{abc}$ | 73.56$^{a}$ | 9.33$^{i}$ | 1.39$^{abcde}$ | 4.88$^{abcde}$ |
| $D_3$ x $I_3$ x $F_2$ | 223.90$^{cd}$ | 69.00$^{defgh}$ | 9.44$^{i}$ | 1.33$^{cdefghi}$ | 4.33$^{bcde}$ |
| $D_3$ x $I_3$ x $F_3$ | 222.30$^{d}$ | 70.78$^{bcde}$ | 12.10$^{cdef}$ | 1.30$^{defghi}$ | 4.22$^{cde}$ |
| Control | 189.67 | 59.72 | 14.09 | 1.24 | 8.33 |
| SE ± | 3.47 | 0.72 | 0.40 | 0.03 | 0.52 |
| CD (0.05) | 9.98 | 2.07 | 1.16 | 0.10 | 1.51 |
| CV% | 12.89 | 18.40 | 15.91 | 14.73 | 17.69 |

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

**Table 3:** Influence of planting distance, irrigation and fertigation levels interactions on growth characters at shooting of ratoon crop

| Treatment | Pseudostem height (cm) | Pseudostem girth (cm) | Number of functional leaves | Leaf area (m²) | Number of suckers/ plant |
|---|---|---|---|---|---|
| Planting distances, irrigation and fertigation levels interactions (A x B x C) | | | | | |
| $D_1$ x $I_1$ x $F_1$ | 213.30$^{g}$ | 57.56$^{c}$ | 10.44$^{bcdef}$ | 1.08$^{def}$ | 3.00$^{ab}$ |
| $D_1$ x $I_1$ x $F_2$ | 225.90$^{defg}$ | 70.56$^{ab}$ | 9.89$^{def}$ | 1.15$^{abcdef}$ | 2.55$^{ab}$ |
| $D_1$ x $I_1$ x $F_3$ | 227.70$^{defg}$ | 73.56$^{ab}$ | 11.11$^{abcde}$ | 1.23$^{abcde}$ | 2.22$^{ab}$ |
| $D_1$ x $I_2$ x $F_1$ | 225.20$^{efg}$ | 69.57$^{ab}$ | 10.00$^{cdef}$ | 1.24$^{abcd}$ | 3.44$^{a}$ |
| $D_1$ x $I_2$ x $F_2$ | 217.10$^{fg}$ | 66.22$^{abc}$ | 8.89 $^{f}$ | 1.21$^{abcde}$ | 2.55$^{ab}$ |
| $D_1$ x $I_2$ x $F_3$ | 230.60$^{cdefg}$ | 69.29$^{ab}$ | 11.00$^{abcde}$ | 1.21$^{abcde}$ | 2.22$^{ab}$ |
| $D_1$ x $I_3$ x $F_1$ | 257.90$^{abcde}$ | 75.33$^{a}$ | 10.22$^{bcdef}$ | 1.18$^{abcdef}$ | 2.78$^{ab}$ |
| $D_1$ x $I_3$ x $F_2$ | 226.40$^{defg}$ | 73.67$^{ab}$ | 10.22$^{bcdef}$ | 1.13$^{def}$ | 2.77$^{ab}$ |
| $D_1$ x $I_3$ x $F_3$ | 214.80$^{fg}$ | 69.22$^{ab}$ | 10.00$^{cdef}$ | 1.18$^{abcdef}$ | 2.55$^{ab}$ |
| $D_2$ x $I_1$ x $F_1$ | 242.60$^{bcdefg}$ | 76.22$^{a}$ | 11.33$^{abcd}$ | 1.18$^{abcdef}$ | 2.33$^{ab}$ |
| $D_2$ x $I_1$ x $F_2$ | 258.70$^{abcd}$ | 66.63$^{abc}$ | 11.78$^{ab}$ | 0.91$^{g}$ | 2.00$^{b}$ |

| | | | | | |
|---|---|---|---|---|---|
| $D_2$ x $I_1$ x $F_3$ | 260.60$^{abc}$ | 71.38$^{ab}$ | 10.44$^{bcdef}$ | 1.18$^{abcdef}$ | 2.00$^{b}$ |
| $D_2$ x $I_2$ x $F_1$ | 214.60$^{fg}$ | 70.56$^{ab}$ | 9.99$^{cdef}$ | 1.23$^{abcde}$ | 2.00$^{b}$ |
| $D_2$ x $I_2$ x $F_2$ | 232.00$^{cdefg}$ | 72.86$^{ab}$ | 10.78$^{bcde}$ | 1.11$^{def}$ | 2.77$^{ab}$ |
| $D_2$ x $I_2$ x $F_3$ | 276.30$^{a}$ | 68.15$^{ab}$ | 10.78$^{bcde}$ | 1.14$^{cdef}$ | 2.00$^{b}$ |

**Table 3:** (Contd…)

| Treatment | Pseudostem height (cm) | Pseudostem girth (cm) | Number of functional leaves | Leaf area (m²) | Number of suckers/ plant |
|---|---|---|---|---|---|
| Planting distances, irrigation and fertigation levels interactions (A x B x C) | | | | | |
| $D_2$ x $I_3$ x $F_1$ | 226.90$^{defg}$ | 70.38$^{ab}$ | 10.67$^{bcde}$ | 1.31$^{a}$ | 2.00$^{b}$ |
| $D_2$ x $I_3$ x $F_2$ | 223.00$^{fg}$ | 73.37$^{ab}$ | 11.00$^{abcde}$ | 1.31$^{ab}$ | 2.00$^{b}$ |
| $D_2$ x $I_3$ x $F_3$ | 215.10$^{fg}$ | 68.22$^{ab}$ | 10.78$^{bcde}$ | 1.18$^{abcdef}$ | 2.00$^{b}$ |
| $D_3$ x $I_1$ x $F_1$ | 270.00$^{ab}$ | 76.51$^{a}$ | 12.55$^{a}$ | 1.30$^{abc}$ | 2.55$^{ab}$ |
| $D_3$ x $I_1$ x $F_2$ | 237.30$^{cdefg}$ | 67.62$^{abc}$ | 11.67$^{abc}$ | 1.06$^{ef}$ | 2.89$^{ab}$ |
| $D_3$ x $I_1$ x $F_3$ | 239.10$^{bcdefg}$ | 67.67$^{abc}$ | 9.55$^{ef}$ | 1.14$^{cdef}$ | 2.22$^{ab}$ |
| $D_3$ x $I_2$ x $F_1$ | 216.80$^{fg}$ | 71.80$^{ab}$ | 10.45$^{bcdef}$ | 1.19$^{abcde}$ | 3.00$^{ab}$ |
| $D_3$ x $I_2$ x $F_2$ | 244.80$^{abcdefg}$ | 75.83$^{a}$ | 11.22$^{abcde}$ | 1.10$^{def}$ | 2.33$^{ab}$ |
| $D_3$ x $I_2$ x $F_3$ | 216.00$^{fg}$ | 66.00$^{abc}$ | 11.22$^{abcde}$ | 1.02$^{fg}$ | 2.22$^{ab}$ |
| $D_3$ x $I_3$ x $F_1$ | 247.40$^{abcdef}$ | 63.11$^{bc}$ | 11.33$^{abcd}$ | 1.09$^{def}$ | 2.55$^{ab}$ |
| $D_3$ x $I_3$ x $F_2$ | 241.80$^{bcdefg}$ | 71.17$^{ab}$ | 10.55$^{bcdef}$ | 1.15$^{bcdef}$ | 2.00$^{b}$ |
| $D_3$ x $I_3$ x $F_3$ | 262.40$^{abc}$ | 69.17$^{ab}$ | 9.66$^{def}$ | 1.20$^{abcde}$ | 2.22$^{ab}$ |
| Control | 219.96 | 55.39 | 11.84 | 1.14 | 3.72 |
| SE ± | 9.63 | 3.16 | 0.49 | 0.04 | 0.35 |
| CD (0.05) | 27.63 | 9.08 | 1.42 | 0.13 | 1.02 |
| CV% | 17.08 | 17.83 | 18.06 | 17.22 | 20.62 |

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

**Table 4:** Influence of planting distance, irrigation and fertigation levels interactions on crop duration (days) of main and ratoon crops.

| Treatment | *Main crop* | | Ratoon crop | |
|---|---|---|---|---|
| | From planting to shooting | Total crop duration | From ratooning to shooting | Total crop duration |
| Planting distances, irrigation and fertigation levels interactions( A x B x C) | | | | |
| $D_1$ x $I_1$ x $F_1$ | 222.20$^{hijk}$ | 322.20$^{hijk}$ | 249.30$^{hijk}$ | 349.30$^{hijk}$ |
| $D_1$ x $I_1$ x $F_2$ | 210.70$^{k}$ | 310.70$^{k}$ | 237.80$^{k}$ | 337.80$^{k}$ |
| $D_1$ x $I_1$ x $F_3$ | 233.90$^{ghijk}$ | 333.90$^{ghijk}$ | 261.00$^{ghijk}$ | 361.00$^{ghijk}$ |
| $D_1$ x $I_2$ x $F_1$ | 215.00$^{ijk}$ | 315.00$^{ijk}$ | 242.10$^{ijk}$ | 342.10$^{ijk}$ |
| $D_1$ x $I_2$ x $F_2$ | 238.60$^{ghijk}$ | 338.60$^{ghijk}$ | 265.70$^{ghijk}$ | 365.70$^{ghijk}$ |
| $D_1$ x $I_2$ x $F_3$ | 232.90$^{ghijk}$ | 332.90$^{ghijk}$ | 260.00$^{ghijk}$ | 360.00$^{ghijk}$ |
| $D_1$ x $I_3$ x $F_1$ | 220.70$^{ijk}$ | 320.70$^{ijk}$ | 247.80$^{ijk}$ | 347.80$^{ijk}$ |
| $D_1$ x $I_3$ x $F_2$ | 249.90$^{fghi}$ | 349.90$^{fghi}$ | 277.00$^{fghi}$ | 377.00$^{fghi}$ |
| $D_1$ x $I_3$ x $F_3$ | 258.90$^{cdefg}$ | 358.90$^{cdefg}$ | 286.00$^{cdefg}$ | 386.00$^{cdefg}$ |
| $D_2$ x $I_1$ x $F_1$ | 260.30$^{bcdefg}$ | 360.30$^{bcdefg}$ | 287.40$^{bcdefg}$ | 387.40$^{bcdefg}$ |
| $D_2$ x $I_1$ x $F_2$ | 246.00$^{ghij}$ | 346.00$^{ghij}$ | 273.10$^{ghij}$ | 373.10$^{ghij}$ |
| $D_2$ x $I_1$ x $F_3$ | 246.70$^{fghi}$ | 346.70$^{fghi}$ | 273.80$^{fghi}$ | 373.80$^{fghi}$ |
| $D_2$ x $I_2$ x $F_1$ | 244.30$^{ghij}$ | 344.30$^{ghij}$ | 271.40$^{ghij}$ | 371.40$^{ghij}$ |
| $D_2$ x $I_2$ x $F_2$ | 254.00$^{defgh}$ | 354.00$^{defgh}$ | 281.10$^{defgh}$ | 381.10$^{defgh}$ |
| $D_2$ x $I_2$ x $F_3$ | 236.60$^{ghijk}$ | 336.60$^{ghijk}$ | 263.70$^{ghijk}$ | 363.70$^{ghijk}$ |
| $D_2$ x $I_3$ x $F_1$ | 250.70$^{efghi}$ | 350.70$^{efghi}$ | 277.80 $^{efghi}$ | 377.80$^{efghi}$ |

**Table 4:** (Contd….)

| Treatment | Main crop | | Ratoon crop | |
|---|---|---|---|---|
| | From planting to shooting | Total crop duration | From ratooning to shooting | Total crop duration |
| Planting distances, irrigation and fertigation levels interactions (A x B x C) | | | | |
| $D_2$ x $I_3$ x $F_2$ | 247.40$^{fghi}$ | 347.40$^{fghi}$ | 274.50$^{fghi}$ | 374.50$^{fghi}$ |
| $D_2$ x $I_3$ x $F_3$ | 250.70$^{efghi}$ | 350.70$^{efghi}$ | 277.80$^{efghi}$ | 377.80$^{efghi}$ |
| $D_3$ x $I_1$ x $F_1$ | 277.90$^{abcdef}$ | 377.90$^{abcdef}$ | 305.00$^{abcdef}$ | 405.00$^{abcdef}$ |
| $D_3$ x $I_1$ x $F_2$ | 290.60$^{ab}$ | 390.60$^{ab}$ | 317.70$^{ab}$ | 417.70$^{ab}$ |
| $D_3$ x $I_1$ x $F_3$ | 285.00$^{abc}$ | 385.00$^{abc}$ | 312.10$^{abc}$ | 412.10$^{abc}$ |
| $D_3$ x $I_2$ x $F_1$ | 286.70$^{abc}$ | 386.70$^{abc}$ | 313.80$^{abc}$ | 413.80$^{abc}$ |
| $D_3$ x $I_2$ x $F_2$ | 263.00$^{bcdefg}$ | 363.00$^{bcdefg}$ | 290.10$^{bcdefg}$ | 390.10$^{bcdefg}$ |
| $D_3$ x $I_2$ x $F_3$ | 283.20$^{abcd}$ | 383.20$^{abcd}$ | 310.30$^{abcd}$ | 410.30$^{abcd}$ |
| $D_3$ x $I_3$ x $F_1$ | 295.00$^{a}$ | 395.00$^{a}$ | 322.10$^{a}$ | 422.10$^{a}$ |
| $D_3$ x $I_3$ x $F_2$ | 299.40$^{a}$ | 399.40$^{a}$ | 326.50$^{a}$ | 426.50$^{a}$ |
| $D_3$ x $I_3$ x $F_3$ | 281.20$^{abcde}$ | 381.20$^{abcde}$ | 288.30$^{abcde}$ | 388.20$^{abcde}$ |
| Control | 299.61 | 399.71 | 336.51 | 436.56 |
| SE ± | 9.35 | 9.35 | 10.24 | 10.24 |
| CD ( 0.05) | 26.84 | 26.84 | 25.98 | 25.98 |
| CV% | 16.36 | 14.57 | 16.19 | 14.48 |

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

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