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INFLUENCES OF DRIP IRRIGATION AND FERTIGATION ON QUALITY PARAMETERS IN BANANA CV. BARJAHAJI (AAA). ASSAM, INDIA.

A. K. Sharmah,
Ph.D. Scholar, Department of Horticulture, AAU, Jorhat-13, Assam, India.

R. Bhattacharyya,
Principal Scientist and Former Head, Department of Horticulture, AAU, Jorhat-13, Assam, India.

ABSTRACT

A study was carried out in the experimental farm as well as in the Laboratory of the Department of Horticulture, Assam Agricultural University, Jorhat to study on quality parameters due to drip irrigation and fertigation in banana cv. Barjahaji (AAA). The treatments consisted of two levels of drip irrigation, viz.; drip irrigation at 1.00EpR (D1) and drip irrigation at 0.75 EpR (D2) and four levels of fertigation, viz. 100% recommended dose of N&K through drip (F1), 75% recommended dose of N&K through drip (F2), 50% recommended dose of N&K through drip (F3) and 100% recommended dose of N&K through soil application (F4). The experimental design was laid out in Randomized Block Design (RBD) with three replications. The results indicated that the highest TSS (26.06 °b), Reducing sugar (7.70%), Non reducing sugar (12.71%), Total sugar (20.41%), Pulp- peel ratio (4.44) and minimum days for ripening were recorded in Drip irrigation at 0.75 EpR and 100% recommended dose of N & K through drip (T_5). The highest Ascorbic acid (6.00%) and Titrable acidity (0.32%) were recorded in T_1 and T_3 (drip irrigation at 1.00 epr and 50% recommended dose of N & K through drip) recorded highest shelf life of fingers. The highest Sugar acid ratio (87.26) was recorded in T_6 (drip irrigation at 0.75 epr and 75% recommended dose of N & K through drip). Hence considering the positive effect on quality parameters, T5 is considered as best but from economic point of view T6 is preferable. So both these treatments are better for adopting at the field level to reap high crop of better quality.

Key Words: Drip irrigation, Fertigation, Banana, Quality parameters.

Introduction:

Banana, a perennial fruit crop belonging to the botanical family Musaceae is the most favourite fruit in India and is a tropical, monocotyledonous, monoecious, monocarpic, mesophytic, herbaceous crop. Its perennial nature is maintained through perpetuation of suckers. By far it is the cheapest yet nutritionally delicious fruit liked by people of all strata and considered as poor man's apple. In many parts of India including Assam the fruits as well as the plants are exclusively used in all auspicious occassions such as wedding, festivals and for worshipping God.

India ranks second in terms of area coverage (491.80 thousand hectares) and ranks first in production (16813.50 thousand tonnes) of banana with the productivity of 34.30 t/ha (Anon, 2003 a). India's production is 15 per cent of the world's total banana production. The major banana growing states include Tamil Nadu, Maharashtra, Karnataka, Bihar, Gujarat, Kerala, Orissa, Madhya Pradesh, Arunachal Pradesh and Assam. Tamil Nadu takes the first position in terms of area of (92.2 thousand hectares) production (4856.4 thousand tones) and productivity of 52.67 t/ha while Assam ranks fourth in area and production producing 602.20 thousand tonnes of banana annually with a productivity of 17.90 t/ha from an area of 43.90 thousand hectares (Anon, 2004).

Banana is more sensitive to moisture stress than any other fruit crops. Among various methods of irrigation, drip irrigation is an advanced irrigation method that permits application of precise and measured quantity of water to every individual plant slowly drop by drop and directly to the root zone of the plant. Since the required quantity of water is supplied as uniform, small continuous flow to a concentrated position of the soil volume, the entire rootzone is kept near field capacity and hence the plants do not get subjected to any stress during the growth period in contrast to the other surface methods of irrigation where fluctuations of soil moisture during an irrigation cycle is observed. About 60-70% of rainfall is lost through evaporation and this can be minimized by application of irrigation. Drip irrigation minimizes the deep percolation, runoff and soil water evaporation, gives increased water application efficiency and thus scarce irrigation water can be used efficiently. As the

drip irrigation system maintains very high soil matric potential in at least a part of the rootzone, without much stress, the growth and productivity of banana can be improved by this method of irrigation. Application of fertilizer along with irrigation water is fairly a new technology of distributing fertilizers to the rootzone or canopy of the fruit crops. it helps in increasing nutrient use efficiency. It also provides some additional benefits in case of quality parameters of fruit crops.

To ensure high quality as well as fertilizer use efficiency of banana, application of adequate amount of irrigation water using efficient method and application of fertilizer are of great importance. Over the years a good deal of research have been conducted by many workers to get a clear understanding of the effect of different levels of irrigation and doses of fertilizers on quality of banana crop. Keeping these facts in view, the present investigation was carried out to study the influence of drip cum fertigation on quality parameters of commercially important banana cv. Barjahaji.

Materials and Methods

Layout and experimental design

The experiment was laid out in Randomized Block Design with three (3) replications comprising (8) treatments. There were twenty four (24) plots each having twelve (12) numbers of plant with the spacing of 1.8 m x 1.8 m. Individual plot size was 38.88 m^2 and the total area of the experimental site was 941.76 m^2.

Treatments:

T_1 (D_1F_1) = (Drip irrigation at 1.00 EpR and 100% recommended dose of N & K through drip)

T_2 (D_1F_2) = (Drip irrigation at 1.00 EpR and 75% recommended dose of N & K through drip)

T_3 (D_1F_3) = (Drip irrigation at 1.00EpR and 50% recommended dose of N & K through drip)

T_4 (D_1F_4) = (Drip irrigation at 1.00 EpR and 100% recommended dose of N & K through soil application)

T_5 (D_2F_1) = (Drip irrigation at 0.75 EpR and 100% recommended dose of N & K through drip)

T_6 (D_2F_2) = (Drip irrigation at 0.75 EpR and 75% recommended dose of N & K through drip)

T_7 (D_2F_3) = (Drip irrigation at 0.75 EpR and 50% recommended dose of N & K through drip)

T_8 (D_2F_4) = (Drip irrigation at 0.75 EpR and 100% recommended dose of N & K through soil application)

Selection of cultivar

'Barjahaji' a leading commercial cv. of banana of the Northeastern region of India was selected as the cv. for study. The horticultural nomenclature of the cv. is Musa (AAA Group, Cavendish sub-group) 'Barjahaji'. Some of the synonyms of this cultivar are 'Tall Jahaji', 'Bangali Jahaji' (Assam) and 'Giant Cavendish' in some other countries.

The plant is medium tall, about 260 cm in average height and the average pseudostem girth is 65 cm. The bunch is more or less cylindrical in shape with about 6-12 numbers of hand which are tightly placed in the peduncle. Unlike Jahaji it was no persistent male bracts. Fingers are long and green in colour. The green colour of the peel is retained even at ripening. The pulp is light cream in colour, soft, sweet, juicy with agreeable flavour. Yield is about 20 kg/bunch. The cv. is susceptible to 'bunchy top' and 'leaf spot' disease but resistant to 'Panama wilt'.

Selection of planting material

Healthy sword suckers of uniform age (4 month), size and weight were collected from healthy mother plants as planting materials.

Time and method of fertilizer application

Irrespective of treatments an uniform dose of nitrogenous, phosphatic and potassic fertilizer @ 110 g N, 33 g P_2O_5 and 330 g K_2O per plant in the form of Urea, SSP and MOP were applied. Urea and MOP were splited into 10 equal doses and were applied as fertigation starting from 3rd month at an interval of 15 days except for T_4 and T_8 (soil application). The whole of SSP fertilizer were applied at 3rd month after planting.

In case of soil application, fertilizers were applied in a circular band of 10 cm depth at a distance of 30 cm and 60 cm in 3rd and 5th month after planting respectively. In case of fertigation the amount of fertilizer to be applied for individual treatment is calculated out on the basis of the per cent recommended dose of the fertilizer along with the required irrigation level and was applied in the rootzone through the drippers.

Layout drip lines

A drip irrigation system was installed at the experimental site as per layout shown in Fig. 3.4. 12 mm diameter LLDPE (linear low density polyethylene) pipes were used as laterals where pressure compensating type, 2LPH size drippers were fitted. The laterals were fitted around each plant. Single dripper was used to irrigate each plant. Prior to installation, test runs were

carried out to verify the design discharge rating of the dripper. The co-efficient of variation of the discharge rate was found to be <0.05 which was classified as good. In order to have the two levels of drip irrigation, lateral values were fitted at the beginning of the laterals used for the irrigation level at 0.75 EpR.

Irrigation schedule under drip system

The drip irrigation was installed in the 3rd month after planting and the average discharge rate of the drippers was determined for normal operating pressure range. Such a calibration eliminates the need of discharge measurements during the crop growing periods. Irrigation was given on alternate days by replenishing the previous two days cumulative pan evaporation losses. Irrigation was withheld for those days, whenever the total rainfall of the previous two days exceeded the cumulative pan evaporation of those days. The evaporation data were collected from the USWB class A pan evaporimeter located in the meteorological observatory of AAU. The irrigation was first given on 1st Nov. 2005 and the last one on 31st March, 2006. The source of irrigation water was a pond and the water was pumped through centrifugal submersible pump into the system.

Harvesting

Harvesting was done uniformly at three forth maturity stage when the ridges of the fingers disappeared and the dark green coloured fingers turned to light green. The peduncle was cut at 22.5 cm above the first hand and 5 cm below the last hand. The mother plant was cut down by leaving about one meter of pseudostem above the ground level.

Quality parameters

Total soluble solids (TSS)

TSS of the fruit samples taken from the second hand was determined by Zeiss Hand juice Brix Refractometer and the result was expressed in °B.

Titrable acidity

Titrable acidity was estimated by using standard method of AOAC (1975). Ten g of pulp was dissolved in 100 ml of distilled water and filtered. Ten ml of filtrate was titrated against 0.1 N NaOH using the indicator phenolpthaleing where the light pink colour indicated the end

point. Titrable acidity was calculated by the following formula and expressed in percentage in terms of anhydrous citric acid.

$$\text{Titrable Acidity} = \frac{\text{Titre value x Normality of alkali x Volume made up x Equivalent weight of citric acid x 100}}{\text{Weight of sample x Aliquot x 1000}}$$

Reducing sugar

Reducing sugar was also estimated by using the standard method of AOAC (1975). Ten ml of standard lead acetate solution and 5 g of sodium oxalate were added to 25 g of pulp which was already grained in a mortar and the volume was made up to 250 ml with distilled water, centrifuged and then filtered. The filtrate was titrated against 10 ml boiling fehling's solution mixture (5 ml of Fehling's solution A + 5 ml of Fehling's solution B) using methylene blue as indicator, where deep brick red colour of the solution indicated the end point. Reducing sugar was calculated by using the following formula and expressed in percentage.

$$\text{Reducing sugar} = \frac{\text{Factor x volume made}}{\text{Titre value x weight of sample}} \times 1000$$

Where, Factor = 0.05 (mg of invert sugar)

Total sugar

It was estimated by using the standard method of AOAC (1975) from the solution of 250 ml made up for estimation of reducing sugar, 50 ml was taken and 5 ml of concentrated HCL was added to it and kept over night. The solution was then neutralized with 1N NaOH and the volume was made up to 150 ml with distilled water and titrated against 10 ml boiling Fehling's solution mixture. Total sugar was calculated with the following formula and expressed as percentage.

Total sugar = (% sucrose + % reducing sugar)

Sucrose = (Total invert sugar % - reducing sugar %) x 0.95

$$\text{Total invert sugar} = \frac{\text{Factor x volume made up x volume stock solution}}{\text{}}$$

$$\text{Factor} = \frac{\text{Titre value x weight of the sample x Aliquot taken}}{0.05 \text{ (mg of invert sugar)}}$$

Non reducing sugar was obtained by subtracting the value of reducing sugar from the value of total sugar. Sugar acid ratio was calculated by dividing the mean of total sugar by the mean of titrable acidity. Pulp peel ratio was calculated by dividing the mean pulp weight by the mean of peel weight.

Ascorbic acid

The 2, 6-Dichlorophenol-Indophenol visual Titration method was followed in estimating the ascorbic acid content of the fruit pulp and the results expressed as percentage.

$$\text{Ascorbic acid (\%)} = \frac{\text{T.V x Dye factor x Volume made up}}{\text{Aliquot taken x weight or volume of sample taken}}$$

Shelf life

Shelf life of the fruit under study was determined by constituting a panel comprising of 7 members. The appearance and texture were observed and scores were given as per the scale given by (Bhowmik and Pann, 1992). For appearance a 9 point scale was used (9 = Excellent, 1 Poor, inedible) and for texture a 5 point scale was used (5 = Fresh, 1 = Soft). Whenever a produce under study reached the score representing the limit of marketability, its shelf life was declared to be terminated.

Ripening days: Days taken by the fruits for ripening under different treatments were recorded.

Result and Discussion

Influence on Quality parameters (Table 1.)

TSS (°Brix)

The effect of drip irrigation and fertigation was significant, however their interaction effect was non-significant. Drip irrigation level D_2 recorded the higher TSS (24.55°B) than D_1

(22.92°B). Among the fertigation levels, F_1 recorded the highest (25.09°B) followed by F_2 (24.29°B), F_4 (23.72°B) and F_3 (21.83°B) recorded the lowest TSS.

Titrable acidity (%)

Significantly difference in titrable acidity of fruits were observed due to drip irrigation as well as fertigation. There was no significant effect of the interaction of drip irrigation and fertigation. Drip irrigation increased the titrable acidity and the highest value was found in D_1 (0.30%) compared to D_2 (0.23%). Among the fertigation levels, F_1 recorded the highest (0.29%) followed by F_2 (0.27%), F_4 (0.26%) and the lowest was recorded in F_3 (0.23%).

Reducing sugar (%)

The different levels of drip irrigation were found to have significant effect on the reducing sugar content of fruits. D_2 recorded the higher value of reducing sugar (7.33%) than D_1 (6.78%). Among the fertigation levels, F_1 recorded highest reducing sugar (7.45%) followed by F_4 (7.22%), F_2 (7.08%) and the lowest was recorded in F_3 (6.47%). Interaction effect of drip irrigation and fertigation was significant D_2F_1 recorded the highest (7.70%) which was at par with D_2F_2 (7.60%). These two treatments were superior to rest of the treatments. D_1F_3 (6.33%) was recorded the lowest reducing sugar.

Non-reducing sugar (%)

Non-reducing sugar content significantly influenced by fertigation and drip irrigation and the interaction of drip irrigation and fertigation was found to be significant. Fruits under drip irrigation level D_2 recorded higher non-reducing sugar (11.07%) than D_1 (9.28%). Among the fertigation levels, F_1 with (11.40%) non-reducing sugar was found to be most effective in increasing non-reducing sugar content followed by F_2 (10.68%), F_4 (10.29%) and F_3 (8.32%) recorded the lowest. Among the treatments, D_2F_1 recorded the highest non-reducing sugar (12.71%) which was followed by D_2F_2 (12.01%) and lowest was recorded in D_1F_3 (8.11%).

Total sugar (%)

Drip irrigation significantly influenced the total sugar content in banana. The higher total sugar content was recorded in D_2 (18.40%) than D_1 (16.05%). Significant increase in total sugar content was observed due to the fertigation. The highest (18.45%) total sugar content was found in F_1 followed by F_2 (17.78%), F_4 (17.51) and the lowest (14.79%) was recorded in F_3. The interaction effect of drip irrigation and fertigation was significant. The treatment D_2F_1

(21.18%) recorded the highest which was at par with D_2F_2 (19.61%). These two treatments were superior to rest of the treatments and the lowest was recorded in D_1F_3 (14.96%).

Ascorbic acid (%)

Both drip irrigation and fertigation had significant influence on ascorbic acid content of the fruits. Among the drip irrigation levels, D_1 recorded (5.83%) which was higher than D_2 (5.31%). Among the fertigation, F_1 recorded the highest (5.75%) ascorbic acid followed by F_2 (5.70%), F_4 (5.53%) and the lowest ascorbic acid was recorded in F_3 (5.30%). The interaction effect of drip irrigation and fertigation was significant. Among the treatments, D_1F_1 recorded the highest ascorbic acid content (6.01%) followed by D_1F_2 and the lowest was recorded in D_2F_3 (5.01%).

Sugar acid ratio

The difference in sugar acid ratio due to drip irrigation was significant. However, effect of fertigation and their interaction effect was non-significant. The sugar acid ratio was found higher (83.93) in D_2 than D_1 (54.84).

Pulp : peel ratio

Drip irrigation significantly increased the pulp: peel ratio of fruits, D_2 recorded higher value (4.20) than D_1 (3.81). Significantly increase in pulp: peel ratio was observed due to fertigation. F_1 with (4.25) followed by F_2 (4.11), F_4 (4.09) and F_3 (3.55) recorded the lowest. The interaction of drip irrigation and fertigation was significant. Among the treatments, D_2F_1 (4.44) recorded the highest pulp : peel ratio which was at par with D_2F_2 (4.43) and D_1F_3 (3.42) recorded the lowest.

Days to ripening

Drip irrigation significantly reduced the time of ripening. D_2 (9.08 days) recorded the least number of days for ripening than D_1 (11.94 days). Among the fertigation levels, F_1 recorded the least number of days for ripening (8.95 days) followed by F_2 (9.62 days), F_4 (10.73 days) days and F_3 recorded the highest number of days for ripening (12.74 days). Among the treatments, D_2F_1 recorded the least number of days for ripening (7.52 days) followed by D_2F_2 (7.03 days) and D_1F_3 recorded the highest number of days for ripening (13.00 days).

Influence on Shelf life (Table 2 and 3)

Appearance (Table 2.)

Both drip and fertigation have significant effect on shelf life of banana. Among the drip levels D_2 recorded very good in case of appearance with a score value of (7.23) which was obtained on 8^{th} day of storage in room condition. Among the fertigation levels, F_3 recorded the highest score value (6.50) which was obtained on 8^{th} day. Among the treatments, D_2F_3 recorded the highest score (8.00) which was obtained on 8^{th} day of storage and lowest was obtained in D_1F_1 (1.82) which was obtained on the 8^{th} day, where the fruits reached the limit of marketability. However, their interaction effect was significant.

Textural quality (Table 3.)

Both drip irrigation and fertigation had significant effect on textural quality. Their interaction was also found to be significant. Datas recorded on 8^{th} day storage showed that among the drip levels, higher score was recorded in D_2 (3.95) which indicates the fruit was moderately fresh and reached the limit of marketability on the 8^{th} day of storage than D_1 (1.50) on the 8^{th} day. Among the fertigation levels, F_3 recorded the highest value (3.51) which was obtained on 8^{th} day of storage and lowest was in F_1 (2.00) on the 8^{th} day. Among the treatments, D_2F_3 recorded the highest score value (5.25) on the 8^{th} day of storage, the fruits under this treatment remain fresh upto the 8^{th} day and the lowest value was obtained under D_1F_1 (1.15) where the fruits become soft and spoil, after 8 days of storage.

Effect of drip irrigation on Quality parameters

Drip irrigation with increasing levels resulted in the production of fruits with lower values of TSS, sugar and sugar acid ratio where as resulted in higher values of Titrable acidity and ascorbic acid. The decrease in TSS and sugar content might be due to frequent application of water (Hedge and Srinivas, 1990). The reduction of TSS and sugar content under higher levels of drip irrigation might also be due to dilution effect with increasing moisture content (Salvin, 1999). Bhattacharyya (1982), Ray (1994) and Deka (2003) also recorded the decrease in TSS and sugar and increased ascorbic acid under higher level of soil moisture. The increased starch hydrolysis in moisture stress condition might be due to increased amount of asparagines because asparagines activates the enzyme (Hart, 1934) which was found to increase with the decrease moisture content. The higher sugar acid ratio observed under drip irrigation at 0.75EpR which may be due to low acidity as compared to the sugar

content and was in conformity with the findings of Salvin (1999) and Deka (2003). Respiration rate increased in low moisture status of the plants as a result of which ripening days decreases in those plants compared to plants with high moisture status. This findings were in conformity with Woodhams and Kozlowski (1954).Shelf life of the fruits gradually decreases as the period of storage increases.It can be ascribed that due to microbial activity there occurs rotting and decaying of the fruits.Higher the moisture content percentage of rotting and decaying increases as microbial activity increases with higher moisture content. As a result of which shelf life of the fruit decreases.

Effect of fertigation on Quality parameters

Plants raised under fertigation produced fruits with increased TSS, sugar, ascorbic acid, sugar acid ratio, pulp peel ratio and acidity of the fruits. The findings are in conformity with the findings of Raskar (2000) in banana. Superior quality under high doses of N and K through drip might be due to involvement of K in carbohydrate synthesis, breakdown and translocation of starch, synthesis of protein and neutralization of physiologically important organic acids (Twyford, 1967).

Again shelf life of the fruits increases in low fertilizer condition as uptake by the fruits is less which decreases the rotting percentage. On the other hand ripening days decreases as respiration rate increases in low fertilizer dose. Fruits under 50% recommended dose of N&K through drip recorded longest shelf life at the end of the storage period while 100% recommended dose of N&K recorded shortest shelf life.

Drip irrigation and fertigation significantly influence on fruit quality TSS, total sugar, reducing sugar, non-reducing sugar, sugar acid ratio, pulp-peel ratio and shelf life were highest and minimum days for ripening were recorded with drip irrigation with 0.75 EpR and 100% recommended dose of N&K through drip, whereas ascorbic acid, titrable acidity were highest with drip irrigation at 1.00 EpR and 100% recommended dose of N&K through drip.

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Table 1. Effect on Quality Parameters of Banana.

Treatment	Quality Parameters								
	TSS (°B)	Titrable acidity (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Ascorbic acid (%)	Sugar acid ratio	Pulp : peel ratio	Days to ripening (days)

T_1	24.11	0.32	7.20	10.80	17.28	6.01	54.00	4.06	10.39
T_2	23.22	0.31	6.56	9.37	15.94	5.97	52.96	3.79	12.53
T_3	21.15	0.26	6.33	8.11	14.44	5.59	57.77	3.42	13.00
T_4	23.19	0.31	7.00	9.56	16.56	5.75	54.69	3.97	12.85
T_5	26.06	0.25	7.70	12.71	20.41	5.49	84.80	4.44	7.52
T_6	25.38	0.24	7.60	12.01	19.61	5.43	84.87	4.43	7.03
T_7	22.52	0.20	6.60	8.53	15.13	5.01	78.41	3.69	12.48
T_8	24.24	0.21	7.43	11.02	18.45	5.30	87.65	4.23	9.60
S.Ed.±	**0.78**	**0.01**	**0.17**	**0.32**	**0.43**	**0.01**	**4.32**	**0.02**	**0.69**
CD at 5%	**NS**	**NS**	**0.37**	**0.68**	**0.92**	**0.03**	**NS**	**0.05**	**0.47**

Table 2. Effect on Shelf-life of Banana at different day of storage (appearance)

Treatment	**Storage (Appearance)**			
	2nd day	**4th day**	**6th day**	**8th day**
T_1	3.08	2.98	2.88	1.82
T_2	5.16	5.15	5.00	4.98
T_3	5.45	5.40	5.30	5.00
T_4	3.67	3.01	2.98	2.94
T_5	3.32	6.00	6.02	5.99
T_6	9.07	8.98	8.01	7.98
T_7	9.32	9.01	8.99	8.00
T_8	8.25	7.02	7.00	6.98
S.Ed.±	0.24	0.33	0.22	0.38
CD at 5%	0.51	0.48	0.35	0.17

Table 3. Effect on Shelf-life of Banana at different day of storage (Textural)

Treatment	**Storage (Textural)**			
	2nd day	**4th day**	**6th day**	**8th day**
T_1	1.05	1.95	1.70	1.15
T_2	3.08	2.00	1.85	1.60
T_3	3.25	2.25	2.22	2.01
T_4	3.06	1.94	1.71	1.25
T_5	1.32	3.00	2.95	2.85
T_6	5.20	5.18	5.00	4.95

T_7	5.52	5.25	5.01	5.00
T_8	3.25	3.22	3.10	3.00
S.Ed.±	0.20	0.28	0.30	0.20
CD at 5%	0.43	0.17	0.22	0.42