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Scheduling of Irrigation and Application of Macro-Nutrients on Growth and Yield of Banana

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Abstract

An experiment was conducted during copping season of 1997-98 on *inceptisol* to maximize water and fertilizer application efficiencies by suitable irrigation scheduling along with the optimum dose, method and time of applications of macro-nutrient elements (NPK). Banana (cv Robusta) suckers of uniform age and size were planted in August at a spacing of 1.5 m × 1.5 m. The pits (size 60 cm × 60 cm × 60 cm) were filled with well decomposed farm yard manure at 10 kg per pit. The experiment was laid out in split plot design with three replications. The treatments were divided into two categories, main (irrigation) and sub-main (fertilizer). The irrigation treatments were categorized month-wise with different combinations of IW/CPE ratio. The IW was fixed at 70.00 mm so the irrigation interval (days) between two successive irrigations depended upon the values of evaporation and amount of rainfall received. The month wise different combination of irrigation (IW/CPE ratio) treatments, for I_1, September—January (0.9), February—March (1.2) and April—June (1.5) ; for I_2, September—January (1.2), February—March (1.5) and April—June (1.8) ; and for I_3 , September—January (1.5), February—March (1.8) and April—June (2.1). Similarly, the different combination of fertilizers (elements of NPK) application, for F_1, normal application through soil during third and fifth month after planting ; for F_2, 50% through soil and 50% through foliar spray during third and fifth months after planting ; for F_3, 50% through soil and 50% through foliar spray during third, fifth and seventh months after planting ; and for F_4, 50% through soil and 50% through foliar spray during third, fifth, seventh and ninth months after planting. The recommended dose of fertilizer for banana, cv Robusta is 400 : 100 : 100 : : N : P : K, kg/ha. The experimental data revealed that the treatment individual I_3 and F_3 and combination I_3. F_3 i.e. irrigation at combination of IW/CPE ratio, 1.5 for September—January, 1.8 for February—March and 2.1 for April—June and fertilizer combination, foliar spray 50% of micro-nutrient on months 3, 5 and 7 after planting of banana was found to be most suitable for the sub-humid climate of Chhattisgarh plain zone.
Key words : Irrigation, Macro-nutrients, Growth, Yield, Banana.

Banana, being a mesophyte, require a huge amount of water because of the large foliage area and high moisture content of the pseudostem. The amount of water to be applied and the interval between successive irrigation depend greatly on the extent of root spread, stage of plant growth, soil and weather factors. The water management practice is essential for obtaining maximum yield keeping other management practices are optimum. The plant growth is directly controlled by plant water stress and only indirectly by soil and atmospheric water stress. So, the water has a major role to play with the morphology of plants. Several workers (2—4) reported that the irrigation interval greatly influenced the morphological characteristics of banana. The methods of irrigation also play a great role in banana cultivation (5). The leaf number, pseudostem circumference also observed to be more than the plants that received more irrigation (6). The timely application of macronutrient and micro-nutrient also influence the leaf number, pseudostem circumference and yield of banana (7, 8). A good harvest of banana is the cumulative effect of adequate water supply and timely application of fertilizers throughout the growing period of the crop (9). The objectives of the study were to maximize water and fertilizer application efficiencies by suitable irrigation scheduling along with the optimum dose, method and time of applications of macro-nutrient elements (NPK).

Methods

The study was conducted at the research-cum-

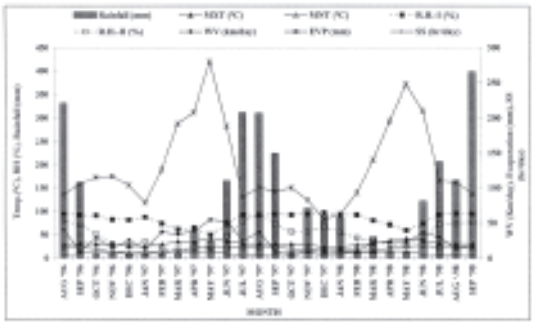

Figure 1. Mean monthly weather data during crop seasons 1996-97 and 1997-98. MXT, Maximum temperature ; MNT, Minimum temperature ; RH, Relative humidity ; EVP, Evaporation ; SS, Sunshine hour ; WV, Wind velocity.

instructional farm of TCB College of Agriculture and Research Station, Sarkanda, Bilaspur Chhattisgarh during two successive cropping seasons of 1996-97 and 1997-98 on *inceptisol.* The soil of the experimental field was clay loam, medium black in color with depth more than 90 cm. The textural composition of the soil consisted of 36.06% sand, 30.14% silt and 33.80% clay. The soil of the experimental area was neutral (normal pH) with the maximum allowable moisture (MAS) 15.14 cm/m. The climate of the region comes under sub-humid having average rainfall of 1,250 mm with 86 rainy days. The minimum and maximum temperature of the area varied from 9.2 to 26.9 and 24.1 to 41.4 C (Fig. 1, Table 1).

Banana (cv Robusta) suckers of uniform age and size were planted in August at a spacing of 1.5 m × 1.5 m. The pits (size 60 cm × 60 cm × 60 cm) were filled with well decomposed farm yard manure at 10 kg per pit. The experiment was laid out in split plot design with three replications. The cropping season cv Robusta was planted in August and harvested after one year in September (14 months). The treatments were divided into two categories, main (irrigation) and sub-main (fertilizer). The irrigation treatments were categorized month-wise with different combination of ratios of irrigation water depth (IW) to the cumulative pan evaporation (CPE), normally termed as IW/CPE ratio. The IW/CPE ratio varied from 0.9 to 2.1 with uniform interval of 0.3. The irrigation treatment IW/CPE = 0.9 means irrigation at every 77.77 mm of CPE. Similarly, IW/CPE ratio, 1.2, 1.5, 1.8 and 2.1 means irrigation at every 58.33, 46.66, 38.88 and 33.33 mm CPE, respectively. The IW was fixed 70.00 mm so that the irrigation intervals (days) between two successive irrigations depend upon the values of evaporation and amount of rainfall received. The month-wise different combination of irrigation (IW/CPE ratio) treatments, for I_1, September—January (0.9), February—March (1.2) and April—June (1.5) ; for I_2, September—January (1.2), February—March (1.5) and April—June (1.8) ; and for I_3, September—January (1.5), February—March (1.8) and April—June (2.1). Similarly, the different combination of fertilizers (elements of NPK) application, for F_1, normal application through soil during third and fifth month after planting ; for F_2, 50% through soil and 50% through foliar spray during third and fifth months after planting ; for F_3, 50% through soil and 50% through foliar spray during third, fifth and seventh months after planting ; and for F_4, 50% through soil and 50% through foliar spray during third, fifth, seventh and ninth months after planting. The recommended dose of fertilizer for Banana, cv Robusta is 400 : 100 : 100 : : N : P : K, kg/ha.

Observations were made three months after planting. The height and girth of the pseudostem were measured at monthly intervals and the values at shooting were used for comparison. The length of the leaf was measured from the axil to the distal tip and the width at the broadest part. The total number of leaves was recorded by counting the leaves that emerged progressively. The sucker production per plant was counted at large, shooting, shot and harvest stages of the crop. The numbers of hand per bunch were recorded. The data were statistically analyzed and interpreted by adopting the methods of Panse and Sukhatme (10).

Results and Discussion

Irrigation

The number of functional leaves increased with the increase in number of irrigation. The I_3 was found better than I_2 and I_1, but I_3 and I_2 was at par to each other (Table 2). The height of pseudostem was observed to be superior in I_3 over I_2 and I_1. The girth of pseudostem increased significantly with

Table 1. Mean monthly weather data during crop season of 1996-97 and 1997-98. MXT, Maximum temperature ; MNT, Minimum temperature ; RH, Relative humidity ; EVP, Evaporation ; SS, Sunshine hour ; WV, Wind velocity.

Months	MXT (^{0}C)	MNT (^{0}C)	RH-I (%)	RH-II (%)	WS (km/ day)	SS (hr/ day)	EVP (mm/ day)	Rain-fall (mm)	EVP (mm)
				1996					
Aug	29.8	24.0	94	80	40.34	3.2	2.9	331.3	90.2
Sep	32.0	23.7	92	70	9.84	7.3	3.5	160.0	105.9
Oct	30.7	19.3	91	51	28.57	8.9	3.7	8.6	115.6
Nov	29.8	13.4	82	31	14.24	9.3	3.9	**9.8**	117.1
Dec	26.6	9.2	81	25	25.24	9.0	3.4	**9.8**	103.9
				1997					
Jan	25.2	10.4	87	35	13.63	8.4	2.5	**9.8**	78.9
Feb	29.5	11.2	73	21	37.03	10.4	4.5	**9.8**	126.2
Mar	35.4	17.5	61	17	33.83	9.3	6.2	**9.8**	191.5
Apr	36.2	20.3	64	24	38.56	9.3	6.9	56.8	207.5
May	40.4	23.9	49	20	54.19	10.2	9.0	36.5	279.9
Jun	36.9	25.5	72	47	52.40	6.5	6.3	165.6	188.0
Jul	30.7	24.4	93	78	24.54	2.5	2.8	311.0	87.4
Aug	30.7	24.4	91	95	36.93	4.3	3.2	309.4	100.4
Sep	30.9	23.8	94	72	9.92	5.8	3.2	224.2	94.6
Oct	30.2	19.9	92	56	3.25	8.3	3.2	12.0	99.9
Nov	29.1	17.9	94	56	10.08	8.0	2.8	106.4	82.5
Dec	24.1	15.5	97	67	10.45	5.3	1.8	91.0	55.2
				1998					
Jan	24.3	13.5	93	55	11.38	6.9	2.0	86.3	62.6
Feb	28.1	14.7	92	43	11.06	9.4	3.3	12.6	93.0
Mar	30.7	16.2	80	36	21.60	9.2	4.5	44.8	140.2
Apr	37.2	21.9	71	29	22.72	10.3	6.5	13.8	195.4
May	41.4	25.4	59	27	22.22	10.0	8.0	12.7	247.6
Jun	38.4	26.9	73	46	36.80	6.0	7.0	121.4	210.0
Jul	31.9	24.8	93	72	29.73	4.4	3.6	206.5	110.4
Aug	31.5	24.9	95	74	13.39	4.6	3.5	166.3	107.9
Sep	31.1	24.1	94	76	16.40	5.9	3.1	398.2	91.5
Oct	30.9	22.6	90	66	10.34	7.3	3.5	133.8	108.9
Nov	27.8	16.7	92	56	13.60	7.6	2.7	84.2	81.1

increased number of irrigations. The number of hands per bunch was also analyzed and found that I_3 was significantly superior in this regard to I_2 and I_1. The yield of banana crop increased significantly with number of Irrigations (Table 3). The irrigation responds well in respect of yield and economics of the banana crops.

The maximum water was applied (280 cm) with 40 number of irrigations in I_3 followed by I_2 (231.0 cm) with 33 irrigations and I_1 (175 cm) with 25 irrigations. The maximum water expanse efficiency (WEE) was noted in I_1 (298.11, kg/ha-cm).

Fertilizer

Application methods of fertilizer not respond significantly with number of functional leaves. In the height of pseudostem character F_3 and F_4 were found to be significantly superior over F_2 and F_1. Although F_1, F_2, F_3 and F_4 were found at par with each other. The girth of pseudostem was also observed that F_3 was found significantly superior

Table 2. Morphological characteristics of banana as influenced by different irrigation regimes and fertilizer levels.

Treatments	Functional leaves (No.) 1996-97	Pseudostem height (cm)	Pseudostem girth (cm)	Hands per bunch (No.)	Functional leaves (No.) 1997-1998	Pseudostem height (cm)	Pseudostem girth (cm)	Hands per bunch (No.)	Functional leaves (No.) Average	Pseudostem height (cm)	Pseudostem girth (cm)	Hands per bunch (No.)
Irrigation												
I_1	10.76	231.84	41.53	5.44	10.02	196.48	38.80	6.88	10.39	214.16	40.17	6.16
I_2	11.30	244.31	48.01	6.67	11.21	223.95	46.79	7.42	11.26	234.13	47.40	7.05
I_3	12.78	262.88	64.16	8.97	11.98	246.00	62.69	8.16	12.38	254.44	63.43	8.57
CD at 5%	0.81	15.29	2.50	0.80	1.26	2.54	5.18	0.74	1.04	8.92	3.84	0.77
CV (%)	6.01	5.48	4.31	10.09	10.02	7.98	7.85	8.79	8.02	6.73	6.08	9.44
Fertilizer												
F_1	11.19	240.62	45.96	6.32	10.65	220.12	44.26	6.82	10.92	230.37	45.11	6.57
F_2	11.42	243.66	48.78	6.32	10.85	223.84	48.23	7.21	11.14	233.75	48.51	6.77
F_3	12.12	250.65	56.40	7.73	11.41	231.82	52.43	8.02	11.77	241.24	54.42	7.88
F_4	11.72	250.44	33.80	7.34	11.39	231.37	52.79	7.90	11.56	240.91	43.30	7.62
CD at 5%	NS	3.72	5.10	0.70	NS	7.50	3.20	1.07	NS	5.61	4.15	0.89
CV (%)	10.23	1.53	5.10	10.14	10.68	8.34	8.55	7.74	10.46	4.94	6.83	8.94

over F_1 and F_2 and found at par with F_4, F_2 and F_1. In respect of number of hand per bunch, F_3 was found significantly superior over F_2 and F_1 but at par with F_4. The yield of Banana was observed that F_3 and F_4 were significantly superior over F_1 but at par with F_2. The treatments F_2 and F_1 were found to be at par with each other.

Interaction Effect of Irrigation and Macro-Nutrients

The maximum yield was recorded in the combi-

Table 3. Treatment-wise yields, water applied and water use efficiency of banana. Effective rainfall during the cropping season = 27.1 cm (1996-97), and 36.46 cm (1997-98), TWA is the total water applied ; WEE is the water expanse efficiency, Parentheses indicated number of irrigation.

Treatments irrigation (I)	Yield (t/ha) Fertilizer (F) F_1 1996-97	F_2	F_3	F_4	Mean	TWA (cm)	WEE (kg/ha-cm)
I_1	46.56	50.57	55.29	56.05	52.17	175.0 (25)	298.11
I_2	56.91	61.62	62.33	63.43	61.15	231.0 (33)	264.71
I_3	65.07	65.78	70.69	68.30	67.46	280.0 (40)	240.92
Mean	56.18	59.48	62.77	62.53	–	–	–
CD at 5%							
I					5.15		
F					4.98		
I × F					NS		
CV (%)							
Irrigation					7.52		
Fertilizers					8.35		

Table 3. Continued.

Treatments irrigation (I)	Yield (t/ha) Fertilizer (F) F_1 1997-1998	F_2	F_3	F_4	Mean	TWA (cm)	WEE (kg/ha-cm)
I_1	44.63	47.59	49.10	50.55	47.96	147.0 (21)	326.25
I_2	50.12	60.91	63.47	63.11	59.52	189.0 (27)	314.92
I_3	64.54	65.25	69.82	66.88	66.62	210.0 (30)	317.23
Mean	53.09	57.72	60.59	60.34	–	–	–
CD at 5%							
I					3.32		
F					3.56		
I × F					NS		
CV (%)							
Irrigation					5.04		
Fertilizers					6.21		

Table 3. Continued.

Treatments irrigation (I)	Yield (t/ha) Fertilizer (F) F_1	F_2	F_3	F_4	Mean	TWA (cm)	WEE (kg/ha-cm)
I_1	45.60	49.08	52.20	53.30	50.07	161.00 (23)	312.18
I_2	53.52	61.27	62.90	63.27	60.34	210.00 (30)	289.82
I_3	64.81	65.52	70.26	67.59	67.04	245.00 (35)	279.08
Mean							
CD at 5%							
I					4.24		
F					4.27		
I × F							
CV (%)							
Irrigation					6.28		
Fertilizers					7.28		

nation treatment of $I_3 \times F_3$ which was significantly higher than all the combination treatments effect except $I_3 \times T_4$ (Table 3).

Conclusion

The data revealed that the treatment individual I_3 and F_3 and combination $I_3 \times F_3$ i.e. irrigation at combination of IW/CPE ratio, 1.5 for September—January 1.8 for February-March and 2.1 for April—June and fertilizer combination, foliar spray 50% of macro-nutrient on months 3, 5 and 7 after planting of banana was found to be most suitable for the sub-humid climate of Chhattisgarh plain zone.

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