

IMPACT OF ROW SPACING AND SOME WEED CONTROL TREATMENTS ON GROWTH, QUALITY AND YIELD OF SUGARCANE

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ABSTRACT

Two field experiments were carried out at Shandaweel Agricultural Research Station, Sohag Governorate in 2007/2008 and 2008/2009 seasons to study the effect of row spacing of sugarcane and some weed treatments on growth, quality and yield. Sugarcane cultivar Phil.8013 was spring-planted in three row spacings of 80, 100 and 120 cm, and ten weed control treatments were applied: single application of Garlon 90% EC at the rate of 2000 cc/fed as post-emergence; Brominal 24% EC at the rate of 1 l/fed as post-emergence; Bazagran 48% AS at the rate of 1 l/fed, 30 days after planting; Granstar 75% DF at the rate of 8 g/fed as post-emergence, at 30 days after planting. The application of each of the four herbicides was followed by one hand hoeing 30 days from herbicide application; hand hoeing three times at 25, 45 and 65 days after planting (DAP) and unweeded (control). A split plot design with three replications was used. Row spacings were allocated in the main plots, while weed control treatments were randomly distributed in the sub-plots.

Results revealed that widening spaces between rows of sugarcane from 80 up to 100 and 120 cm resulted in a significant and gradual increase in dry weight of narrow and broad leaved weeds as well as total weeds/m² in both seasons. There was a significant influence of the applied weed treatments on dry weight/m² of both narrow and broad-leaved weeds and total weeds/m². The results showed that the most effective treatment in eliminating both narrow and broad-leaved weeds was hand hoeing three times, followed by the application of the used herbicides combined with one hand hoeing, and the application of each herbicide alone.

Growing sugarcane in rows spaced at 80-cm apart resulted in a significant increase in stalk height, number of millable canes, cane and sugar yields/fed. The thickest cane stalks were produced from plants grown at 120 cm. Row spacing rows at 100 cm gave the highest values of brix, sucrose, juice purity and sugar recovery percentages. Practicing hand hoeing three times 25, 45 and 65 DAP to get rid of weeds associated with sugarcane plants resulted in the highest values of the studied traits, while the unweeded plots gave the lowest ones. Under the conditions of the present work, growing sugarcane, in rows spaced at 80 or 100 cm and controlling accompanied weeds by manual hoeing three times at 25, 45 and 65 DAP, Brominal + hand hoeing once and/or Garlon + hand hoeing once can be recommended for getting the highest cane and sugar yields/fed. Meanwhile, economic evaluation of the studied factors showed that planting sugarcane in rows of 80-cm apart as well as controlling weeds by applying Brominal herbicide + hand hoeing once or manual hoeing three times gave the highest values of net income and profitability %.

Key words: growth, quality, row spacing, sugar cane, weed control, yield.

1. INTRODUCTION

Row spacing has a direct effect on plant population. It plays a distinct role in the amount of solar radiation intercepted and density, hence, crop canopy development which in turn affects photosynthesis and ultimately the dry matter produced by plant. Also, it may affect cane diameter, length and weight which contribute to cane yield. Avtar *et al.* (2001) mentioned that sugarcane planted at a row spacing of 75 cm gave significantly higher cane yield compared to 90 cm row spacing. El-Geddawy *et al.* (2002-a) found

that narrow row spacing (100 cm) produced higher number of millable canes, cane and sugar yields compared to 120 and/or 140-cm row spacing. Their results showed that the wider row spacing (140 cm) significantly recorded thicker stalks, compared with those of narrower spacing of 100 cm. El-Geddawy *et al.* (2002-b) showed that the widest row spacing gave the highest sucrose, and sugar recovery percentages. Raskar and Bhoi (2003) studied the effect of intra-row spacing (30, 60 or 90 cm). and showed that cane girth and number of millable canes were significantly

higher with a 90-cm intra-row spacing compared with 30 or 60-cm intra-row spacing. Millable cane height and average number of internodes/plant were not significantly affected by spacing. Sundara (2003) grew sugarcane in rows spaced at 90, 120 or 150 cm. and found that spacing of 90 cm resulted in the highest number of stalks at harvest. Juice quality traits were not significantly affected by spacing. Rizk *et al.* (2004-a) found that sucrose was insignificantly affected by the studied row distances (100, 120 and 140 cm). Rizk *et al.* (2004-b) showed that the widest row distance significantly gave the thickest stalks. El-Shafai and Ismail (2006) planted sugarcane in rows of 80, 100 and 120-cm width and found that growing sugarcane in rows of 80-cm apart attained a significant increase in stalk height, number of millable canes, cane and sugar yields/fed. However, stalk diameter increased with 120-cm spacing. Sucrose and sugar recovery percentages were insignificantly affected by row spacing. Singh *et al.* (2006) found that the highest number of millable canes (128000/ha) and cane yield (62.9 tons/ha) were recorded at 45 cm spacing followed by 60 cm (119400/ha and 58.2 tons/ha) and 75 cm (112300/ha and 55.0 tons/ha). Ahmed and Khaled (2008) indicated that planting sugarcane in rows spaced at 80 cm attained significant increases in millable cane length, number of millable cane, cane and sugar yields/fed, compared with 100 and 120 cm spacings. Total soluble solids, sucrose and sugar recovery percentages were not affected by row spacing.

Ibrahim (1984) indicated that losses up to 40% of cane yield were caused by weed populations. Ali *et al.* (1986) found that weed competition decreased millable stalks by 32% and stalk thickness by 15%. Johnson grass and tall perennial grasses decreased cane yield by 36% and sugar yield by 31% compared to weed-free plots. As far as weed control treatments, Singh *et al.* (2001) revealed that all the herbicides and hand weeding treatments increased cane yield. Attalla and Sogheir (2003) controlled weeds by the application of Metribuzin at 300 g/fed at 30 days after planting (DAP); Glufosinate at 2 litre/fed (30 DAP) + 2 litre/fed (60 DAP); hand hoeing 4 times (45, 75, 105 and 140 DAP) compared to the untreated plots. They found that hand hoeing 4 times was the best control treatment for broadleaved weeds at 90 and 150 DAP, followed by Metribuzin and Glufosinate. They added that hand hoeing 4 times gave the highest yield of sugarcane (49.67 tons/fed), which was higher than the control by 26.71% in the first season, and by 24.96% in the second one. Saini *et al.* (2003) found that hand weeding at 30, 60 and 90 DAP had the highest weed control efficiency, where it had the lowest weed population/m² and weed dry matter. Meantime, it gave the highest millable

cane and cane yield/ha. Singh and Kaur (2003) revealed that three hand hoeings and the application of Sencor 70 WP as pre-emergence followed by 2,4 D (sodium salt 80%) as post-emergence, each at 2.0 kg/ha and Round up at 3.0 litre/ha as post-emergence produced significantly higher cane yield/ha. Raskar (2004) observed significant reduction in weed density and weed dry matter at 120 DAP with the pre-emergence application of Metribuzin 1.5 kg/ha supplemented with post emergence application of 2,4 D Na salt 1 kg/ha. The aforesaid treatment gave the highest cane and commercial cane sugar yields, which were 36.32 and 50.10% higher than weedy check, respectively. In order of economics, pre-emergence application of Metribuzin ranked the second. Manuel and Panneerselvam (2005) found that hand hoeing at 30 DAP and Atrazine (2 kg ai/ha) were good for controlling all weeds. Singh and Menhi (2008) indicated that plots receiving manual hoeing at 20, 40 and 60 DAP resulted in minimum weed density (58.3/m²) as well as weed dry matter (15.1 g/m²) and thus proved highly effective. The highest weed control efficiency at 60, 90 and 120 DAP worked out to be 42.6, 58.5 and 67.8%, respectively under this treatment. Fakkar *et al.* (2009) showed that hand hoeing once 45 DAP, hand hoeing twice 45 and 65 DAP and hand hoeing three times 25, 45 and 65 DAP, the separate application of herbicides: Triclopyr at the rate of 200 cm/fed, Florasulam + Flumetsulam at the rate of 30 cm/fed, Fluroxypyr at the rate of 200 cm/fed and Diuron at the rate of 2 kg/fed, and each of the aforementioned herbicides plus one hand hoeing at 65 DAP had a significant effect on narrow, broad leaved and total weeds. Weed control treatments significantly affected stalk height and diameter, brix, sucrose and sugar recovery percentages as well as millable canes, cane and sugar yields. Using Diuron + one hand hoeing resulted in the highest values of these traits as compared to the unweeded treatment.

The aim of the present work was to find out the best row spacing and the best effective weed treatment to obtain the highest yield and quality of sugarcane.

2. MATERIALS AND METHODS

Two field experiments were carried out at Shandaweel Agricultural Research Station, Sohag Governorate in 2007/2008 and 2008/2009 to study the effect of row spacing of sugarcane and some weed control treatments on growth, quality and yield of sugarcane. Sugarcane cultivar Phil.8013 was planted in rows spaced at 80, 100 and 120 cm. The following weed control treatments were applied:

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1. Garlon 90% E.C. (Triclopyr) at the rate of 200 cc/fed as post-emergence, at 30 days after planting.
2. Brominal 24% EC (Bromoxynil) at the rate of 1 l/fed as post-emergence, at 30 days after planting.
3. Bazagran 48% AS (Bentazon) at the rate of 1 l/fed, 30 days after planting.
4. Granstar 75 % DF (Tribenuron-methyl) at the rate of 8 g/fed as post-emergence, at 30 days after planting.
5. Garlon followed by hand hoeing once after 30 days from herbicide application.
6. Brominal followed by hand hoeing once after 30 days from herbicide application.
7. Bazagran followed by hand hoeing once after 30 days from herbicide application.
8. Granstar followed by hand hoeing after 30 days from herbicide application.
9. Hand hoeing three times at 25, 45 and 65 days after planting.
10. Unweeded (control).

Trade, common and chemical names of the used herbicides are presented in Table (1).

A split plot design with three replications was used. Row spacings were allocated in the main plots, while weed control treatments were randomly distributed in the sub-plots. The sub-plot area was 60 m², including 15, 12 and 10 rows of 5 m in length, in case of spacing at 80, 100 and 120 cm, respectively. Two rows of three-budded cane cuttings were used in planting of sugarcane on the 25th of March in the 1st season and 15th of March in the 2nd one, and harvested after 12 months in both seasons. The previous cultivated crop was maize followed by fallow. Soil chemical and mechanical analysis of the experimental site showed that the upper 30-cm of the soil was sandy loam which consisted of (56.34 and 51.57 % sand), (28.44 and 26.30 % silt) and (15.22 and 22.13 % clay) and contained (24.0 and 21), (11.7 and 12.2) and (210 and 186) ppm N, P, K with pH of (7.5 and 7.6) in the 1st and 2nd season, respectively. Recommended doses of P and K

fertilizers were added during seed bed preparation at rates of 30 kg P₂O₅ as calcium super phosphate 15.5% and 72 kg K₂O as potassium sulphate 48% K₂O/fed, respectively, while N fertilizer was added in the form of Urea (46.5 % N) in two equal doses, two months after planting and one month after the 1st one. The other agricultural operations were practiced as recommended by Sugar Crops Research Institute.

2.1. Recorded data

2.1.1. Weed measurements

Weeds from one m² in each plot were pulled out after 95 days from planting, separated to broad and narrow leaved weeds and air dried for seven days then oven dried at 70°C until a constant weight to record the following items:

1. Dry weight of narrow leaf weeds (g/m²).
2. Dry weight of broad leaf weeds (g/m²).
3. Dry weight of total narrow-and broad leaf weeds (g/m²).

2.1.2. Sugarcane traits

At harvest, a sample of 20 stalks from each treatment was taken at random and the following data were recorded:

1. Stalk height (cm).
2. Stalk diameter (cm).
3. Brix % of juice was determined in laboratory using brix hydrometer.
4. Sucrose % of juice was determined using saccharometer according to AOAC (1995).
5. Purity percentage was calculated according to the following equation:

$$\text{Purity \%} = \text{sucrose \%} / \text{brix \%} \times 100$$

6. Sugar recovery percentage was calculated as follows:

$$\text{Sugar recovery \%} = \text{richness \%} \times \text{purity \%}$$

$$\text{Richness} = (\text{sucrose in 100 g of juice} \times \text{factor}) / 100$$

$$\text{Factor} = 100 - [\text{fiber\%} + \text{physical impurities\%} + \text{percent water free from sugar}].$$

Sugar canes of guarded rows were harvested, cleaned, topped to determine:

7. Number of millable canes/fed.
8. Cane yield (ton/fed).

Table(1): Trade, common and chemical names of the herbicides used in the experiment.

Trade name	Common name	Chemical name
1. Garlon 90 % E.C	Triclopyr	Triclopyr [3,5,6 trichloro-2- pyridyloxy acetic acid]
2. Brominal 24% EC	Bromoxynil	{3,5-dibromo-4-hydroxy-benzonitrile}
3. Bazagran 48% AS	Bentazon	3-(1-methylethyl)-(1H)-2,1-3 Benzo-thiadiazin-4(3H)-one 2,2-(dioxide).
4. Granstar 75 % DF	Tribenuron-methyl	[Methyl 2-(N- (4-methoxy - 6 - methyl - 1, 3, 5 triazin 2 -cultivars [13, 14]. Y) methylamine) caronyl) amino) sulful) benzoate

9. Sugar yield (ton/fed), which was estimated according to the following equation:

$$\text{Sugar yield (ton/fed)} = \text{cane yield (ton/fed)} \times \text{sugar recovery \%}$$

The collected data were statistically analyzed according to the method of Snedecor and Cochran (1981).

2.1.3. Economic evaluation

Economic evaluation for the results was done to investigate the variations among the different studied combinations to get the highest profitability using some economic criteria. Economic criteria were calculated according to the following formulae described by Buckett (1981):

1. Gross income (total revenue of cane yield) was calculated as formulas:

$$\text{Gross income} = \text{cane yield (ton/fed)} \times \text{price of one ton.}$$

2. Net income (NI) = Gross income (GI) – total costs (TC).

3. Profitability % = $\text{NI/TC} \times 100$.

3. RESULTS AND DISCUSSION

3.1. Dry weight of weeds

Dry weight of narrow, broad-leaved weeds and their total dry weight/m² as affected by row spacing of sugarcane, weed control treatments and their interactions, at 95 days after planting are recorded in (Tables 2, 3 and 4). Data revealed that widening spaces between rows of sugarcane from 80 to 100 and 120 cm resulted in a significant and gradual increase in dry weight of narrow and broad-leaved weeds, as well as, the total weeds/m² in both seasons. This result is probably due to the fact that increasing distance between cane rows guaranteed more area, nutrients, water and solar radiation for weed plants to grow well. Moreover, increasing row spacing decreased shading and competition of sugarcane plants with weeds, and hence assured better growth conditions.

Data in Tables (2 and 3) pointed to a significant influence of the applied weed treatments on dry weight/m² of both narrow and broad-leaved weeds in the 1st and 2nd seasons. Results in Table 2 manifested that the reduction percentage in dry weight/m² of narrow-leaved weeds as affected by the single application of herbicides was 33.1, 29.6, 27.3 and 24.8 % for Garlon, Brominal, Bazagran and Granstar, respectively. However, adding one hoeing to each of these herbicides, raised the values of the reduction percentages to 88.4, 88.0, 83.5 and 86.0 %, respectively compared with the control, in the 1st season. These results are in agreement with those mentioned by Manuel and Panneerselvam (2005) and Fakkar *et al.* (2009).

Thereafter, the following hand hoeing got rid of a large number of later emerged weeds. In the same season, eradication percentage in dry weight of narrow-leaved weeds/m² was 92.9 % in the case of practicing three hand hoeings. Similar results were found in the 2nd season. In the same respect, Saini *et al.* (2003) and Singh and Menhi (2008) found that hand weeding had the highest weed control efficiency and resulted in minimum weed density and weed dry matter.

Data in Table (3) reveal that reduction percentage in dry weight/m² of broad-leaved weeds as responded to the single application of Garlon, Brominal, Bazagran and Granstar herbicides was 67.0, 66.1, 64.5 and 58.6 %. However, following each herbicide treatment with one hoeing raised the reduction percentages to 95.4, 95.1, 94.5 and 94.2.0 %, respectively, compared with the unweeded plots, in the 1st season. These results are in agreement with those mentioned by Manuel and Panneerselvam (2005) and Fakkar *et al.* (2009). Meantime, reduction percentage in dry weight of broad-leaved weeds/m² was 96.3 % in the case of practicing

three hand hoeings alone. Similar results were recorded in the 2nd season. These results showed the effectiveness of hand hoeing in eliminating both narrow and broad-leaved weeds. These results are in harmony with those reported by Saini *et al.* (2003) and Singh and Menhi (2008). In addition, it can be noticed that the effectiveness of the used herbicides expressed as reduction percentage was higher in the case of broad-leaved weeds than narrow-leaved ones because these herbicides are recommended mainly for broad-leaved weeds.

Results in Table (4) clear that the total dry weight of weeds/m² similarly responded to the applied weed control treatments as shown before.

Data in Tables (2, 3 and 4) show that the interaction between row spacing and weed treatments had a significant effect on dry weight/m² of narrow and broad leaved weeds and the total dry weight of weeds, in both seasons. It was observed that the lowest values of dry weight of weeds/m² were obtained by hoeing weeds manually three times, while allowing weeds to grow freely (control) among rows of sugarcane spaced at 120-cm resulted in the highest dry weight/m² in the three cases.

3.2. Sugarcane characters at harvest time

3.2.1. Growth characters (stalk height, diameter and number of millable canes/fed)

The results showed that increasing row spacing from 80 to 100 and 120 cm led to a

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Table (2): Dry weight of narrow-leaved weeds (g/m²), as affected by weed treatments, row spacing of sugarcane and their interactions, at 95 days after planting, in 2007/2008 and 2008/2009 seasons

Weed control treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100 cm	120 cm	Mean	80 cm	100 cm	120 cm	Mean
Garlon	219.13	235.33	329.27	261.24	218.40	227.90	236.47	227.59
Brominal	233.17	240.87	350.83	274.96	224.93	235.07	271.23	243.74
Bazagran	231.90	249.00	370.47	283.79	229.73	247.77	286.47	254.66
Granstar	234.77	255.47	390.97	293.73	239.03	264.23	302.43	268.57
Garlon and hand hoeing once	25.30	47.27	62.33	44.97	24.57	29.33	35.03	29.64
Brominal and hand hoeing once	23.40	55.50	61.33	46.74	22.03	26.50	45.20	31.24
Bazagran and hand hoeing once	41.37	72.97	78.07	64.13	25.07	30.50	50.53	35.37
Granstar and hand hoeing once	43.93	45.13	74.27	54.44	27.90	35.20	56.83	39.98
Hand hoeing three times	18.47	27.40	36.63	27.50	15.83	26.43	38.07	26.78
Untreated (control)	260.43	385.70	525.67	390.60	295.70	442.77	547.10	428.52
Mean	133.19	161.46	227.98		132.32	156.57	186.94	

LSD at 0.05 level for:

Row spacing (A)	3.03	11.03
Weeding treatments (B)	12.53	13.06
(A) x (B)	21.70	22.63

Table (3): Dry weight of broad-leaved weeds (g/m²), as affected by weed control treatments, row spacing of sugarcane and their interactions, at 95 days after planting, in 2007/2008 and 2008/2009 seasons

Weed control treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100 cm	120 cm	Mean	80 cm	100 cm	120 cm	Mean
Garlon	105.00	146.70	234.00	161.90	109.20	164.93	210.50	161.54
Brominal	115.90	153.00	230.37	166.42	118.20	182.43	223.00	174.54
Bazagran	120.63	160.50	241.43	174.19	140.17	194.50	229.70	188.12
Granstar	125.50	170.50	313.73	203.2	175.63	207.83	249.03	210.83
Garlon and hand hoeing once	16.30	23.27	28.13	22.57	35.10	54.37	61.80	50.42
Brominal and hand hoeing once	17.40	22.47	31.53	23.80	38.67	59.77	45.90	48.11
Bazagran and hand hoeing once	19.57	24.67	35.87	26.70	22.20	26.67	28.77	25.88
Granstar and hand hoeing once	20.57	25.90	38.63	28.37	28.87	33.07	40.90	34.28
Hand hoeing three times	11.13	16.40	26.93	18.16	19.30	22.20	26.63	22.71
Untreated (control)	353.33	466.17	655.07	491.52	425.17	543.10	640.70	536.32
Mean	90.53	120.96	183.57		111.25	148.89	175.69	

LSD at 0.05 level for:

Row spacing (A)	16.73	10.11
Weeding treatments (B)	15.76	12.82
(A) x (B)	27.30	22.20

Table (4): Dry weight of total weeds (g/m²) as affected by weed control treatments, row spacing of sugarcane and their interactions, at 95 days after planting, in 2007/2008 and 2008/2009

Weed control treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100 cm	120 cm	Mean	80 cm	100 cm	120 cm	Mean
Garlon	324.13	382.03	563.27	423.14	327.60	392.83	446.97	389.13
Brominal	349.07	393.87	581.20	441.38	343.13	417.50	494.23	418.29
Bazagran	352.53	409.50	611.90	457.98	369.90	442.27	516.17	442.78
Granstar	360.27	425.97	704.70	496.98	414.67	472.07	551.47	479.40
Garlon and hand hoeing once	41.60	70.53	90.47	67.53	59.67	83.70	96.83	80.07
Brominal and hand hoeing once	40.80	77.97	92.87	70.54	60.70	86.27	91.10	79.36
Bazagran and hand hoeing once	60.93	97.63	113.93	90.83	47.27	57.17	79.30	61.24
Granstar and hand hoeing once	64.50	71.03	112.90	82.81	56.77	68.27	97.73	74.26
Hand hoeing three times	29.60	43.80	63.57	45.66	35.13	48.63	64.70	49.49
Untreated (control)	613.77	851.87	1180.7	882.12	720.87	985.87	1187.8	964.84
Mean	223.72	282.42	411.55		243.57	305.46	362.63	

LSD at 0.05 level for:

Row spacing (A)	19.67	10.05
Weeding treatments (B)	20.70	18.99
(A) x (B)	35.86	32.89

significant decrease in cane stalk height (Table 5) and number of millable canes/fed (Table 7) as well as an appreciable increase in stalk diameter (Table 6), in the 1st and 2nd seasons. These results could be due to the competition among cane plants grown in narrower rows for growth elements, *i.e.*, nutrients, water and sun light. Chang (1974) explained that the proportion of invisible solar radiation is so much increased than the visible solar radiation due to dense sowing. The former has an elongation effect and hence accounts for the increase in stalk height observed, herein; the decrease in stalk diameter when sugarcane was planted in close spaced rows. The same finding was reported by Mohamed and Ismail (2002), who found that cane stalk height increased, while stalk diameter decreased with decreasing row spacing from 150 to 90 cm. Moreover, Rizk *et al.* (2004-b) showed that the widest row distance significantly gave the thickest stalks when planting sugarcane in row distances of 100, 120 and 140 cm. Also, El-Shafai and Ismail (2006) obtained the same results when they grew sugarcane in rows spaced at 80, 100 and 120 cm. Moreover, the reduction in

the number of millable canes/fed accompanying the increase in the distance between cane rows could be attributed to that widening distance between rows decreased the density of planted seeds (cane cuttings). This result is in agreement with those mentioned by El-Geddawy *et al.* (2002-a) and Sundara (2003).

The present results pointed out that cane stalk height and diameter were significantly affected by the used weed control treatments in the 1st and 2nd seasons. The highest values of both stalk characters were obtained by practicing three hand hoeings to get rid of the associated weeds with sugarcane, which decreased weed growth and hence their competition to cane plants. However, the lowest values of the three traits were recorded in the unweeded plots due to the severe competition of weeds with sugarcane plants. These results are in agreement with those found by Ali *et al.* (1986), Saini *et al.* (2003) and Fakkar *et al.* (2009).

Stalk height and diameter were insignificantly influenced by the interaction between row spacing and weed control treatments in both seasons.

3.2.2. Quality characteristics (brix, sucrose, purity and sugar recovery percentages)

The results in Tables (8, 9, 10 and 11) indicate that brix, sucrose, purity and sugar recovery percentages were significantly affected by row spacing of sugarcane in the 1st and 2nd seasons. The results showed that spacing rows of sugarcane at 100 cm resulted in the highest values of the four quality traits, while the lowest brix and sucrose percentages were recorded by cane stalks grown in rows of 120-cm apart, in both seasons. The same result was obtained for purity % in the 1st season. However, in the 2nd season, the lowest purity % was given by canes planted in rows spaced at 80 cm, likewise the lowest sugar recovery % was given by canes grown in 80-cm rows. Moreover, insignificant variance was noticed between row spacing of 80 and 120 cm in sucrose, purity and sugar recovery percentages in the 2nd season.

The results in Tables (8, 9, 10 and 11) reveal that the applied weed control treatments had significant effects on brix, sucrose, purity and sugar recovery percentages in the 1st and 2nd seasons. With the exception of purity % in the 1st season, the highest values of the four traits were obtained by practicing three hand hoeings to get rid of accompanied weeds to sugarcane, which insured the best growth conditions free of weed competition with cane plants, which was positively reflected on more photosynthesis and sugar accumulation in stalks. On the contrary, the lowest values of the studied quality characteristics were given by cane plants suffered from being grown among severe competition with weeds left to grow without any control. Insignificant differences were found in brix% and sucrose% as affected by the single application of Garlon and Brominal herbicides and/or each of Bazagran and Granstar followed by one hand hoeing. Also, there were insignificant differences in sugar recovery % by applying any of the studied herbicides singly. Moreover, insignificant differences were detected in brix, sucrose and sugar recovery percentages in the case of applying each of Garlon and Brominal herbicides followed by hoeing once and practicing three hand hoeings. These results are in line with those stated by Fakkar *et al.* (2009).

The studied quality traits were insignificantly influenced by the interactions among row spacings and weed control treatments in both seasons.

3.2.3. Sugarcane yields

3.2.3.1. Cane yield

Data in Table (12) show that cane yield was significantly affected by row spacing in the 1st and 2nd seasons. The results pointed out that growing sugarcane in rows of 80-cm apart produced 0.61

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Table (5): Stalk height (cm) of sugarcane at harvest, as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons

Treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100 m	120cm	Mean	80 cm	100cm	120cm	Mean
Garlon	291.67	288.33	283.67	287.89	292.67	291.67	287.33	290.56
Brominal	292.67	285.67	281.67	286.67	295.67	288.00	284.67	289.44
Bazagran	289.33	283.00	279.67	284.00	289.00	286.00	283.67	286.22
Granstar	286.00	281.67	278.33	282.00	288.67	284.67	281.00	284.78
Garlon and hand hoeing once	297.33	295.33	292.67	295.11	301.33	299.00	295.00	298.44
Brominal and hand hoeing once	295.33	293.00	290.67	293.00	299.33	297.00	290.00	295.44
Bazagran and hand hoeing once	294.00	290.33	285.67	290.00	297.00	295.00	288.67	293.56
Granstar and hand hoeing once	293.33	288.67	283.33	288.44	296.00	292.00	29300	293.67
Hand hoeing three times	304.67	301.33	297.67	301.22	308.00	305.00	303.33	305.44
Untreated (control)	284.00	277.67	275.33	279.00	287.33	281.67	277.00	282.00
Mean	292.83	288.50	284.87		295.50	292.00	288.37	

LSD at 0.05 level for:

Row spacing (A)	0.72	0.74
Weeding treatments (B)	1.94	2.70
(A) x (B)	NS	NS

Table (6): Stalk diameter (cm) of sugarcane at harvest, as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons

Treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100cm	120cm	Mean	80 cm	100cm	120 m	Mean
Garlon	2.64	2.67	2.73	2.68	2.66	2.62	2.67	2.65
Brominal	2.65	2.68	2.71	2.68	2.67	2.70	2.75	2.71
Bazagran	2.59	2.62	2.69	2.64	2.62	2.70	2.73	2.68
Granstar	2.55	2.61	2.71	2.62	2.59	2.63	2.76	2.66
Garlon and hand hoeing once	2.61	2.72	2.78	2.70	2.65	2.73	2.80	2.73
Brominal and hand hoeing once	2.63	2.69	2.75	2.69	2.68	2.72	2.78	2.73
Bazagran and hand hoeing once	2.61	2.66	2.71	2.66	2.64	2.71	2.75	2.70
Granstar and hand hoeing once	2.59	2.62	2.73	2.65	2.62	2.68	2.80	2.70
Hand hoeing three times	2.64	2.72	2.79	2.72	2.65	2.69	2.83	2.72
Untreated (control)	2.41	2.50	2.55	2.49	2.48	2.66	2.60	2.58
Mean	2.59	2.65	2.71		2.63	2.68	2.75	

LSD at 0.05 level for:

Row spacing (A)	0.04	0.03
Weeding treatments (B)	0.04	0.06
(A) x (B)	NS	NS

Table (7): Number of millable canes (thousand/fed) at harvest, as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons

Treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100cm	120cm	Mean	80 cm	100cm	120cm	Mean
Garlon	51.39	49.15	47.68	49.41	52.56	50.53	49.10	50.73
Brominal	50.56	47.93	46.21	48.23	51.51	49.55	47.15	49.40
Bazagran	49.76	47.57	44.67	47.33	49.70	47.10	46.29	47.70
Granstar	48.31	47.61	45.28	47.07	47.79	46.19	46.48	46.82
Garlon and hand hoeing once	52.57	51.36	46.85	50.26	50.23	51.24	48.67	50.71
Brominal and hand hoeing once	52.84	52.99	49.97	51.94	52.29	51.84	49.85	51.33
Bazagran and hand hoeing once	51.66	50.86	46.87	49.80	51.90	50.71	47.12	49.91
Granstar and hand hoeing once	51.87	49.09	47.04	49.33	52.41	49.47	46.59	49.49
Hand hoeing three times	54.74	52.86	50.37	52.65	52.65	53.04	50.69	52.13
Untreated (control)	44.45	43.58	41.64	43.22	44.58	44.13	40.58	43.09
Mean	50.81	49.30	46.66		50.76	49.38	47.25	

LSD at 0.05 level for:

Row spacing (A)	1.11	0.89
Weeding treatments (B)	1.08	1.07
(A) x (B)	NS	NS

Table (8): Brix % of sugarcane juice at harvest, as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons

Treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100 cm	120 cm	Mean	80 cm	100 cm	120 cm	Mean
Garlon	19.67	20.05	19.60	19.77	19.87	20.07	19.82	19.92
Brominal	19.72	20.07	19.67	19.82	20.02	20.15	19.83	20.00
Bazagran	19.63	19.99	19.58	19.74	19.75	19.87	19.60	19.74
Granstar	19.57	19.87	19.52	19.65	19.68	19.78	19.67	19.71
Garlon and hand hoeing once	19.97	20.15	19.86	19.99	20.23	20.37	20.07	20.22
Brominal and hand hoeing once	20.00	20.23	19.90	20.04	20.25	20.50	20.12	20.29
Bazagran and hand hoeing once	19.78	20.10	19.75	19.88	19.95	20.03	19.87	19.95
Granstar and hand hoeing once	19.72	20.10	19.65	19.82	19.87	19.88	19.72	19.82
Hand hoeing three times	20.07	20.27	19.87	20.07	20.43	20.55	20.17	20.38
Untreated (control)	15.73	15.83	15.57	15.71	16.02	16.12	15.85	15.99
Mean	19.39	19.67	19.30		19.61	19.73	19.47	

LSD at 0.05 level for:

Row spacing (A)	0.10	0.04
Weeding treatments (B)	0.13	0.17
(A) x (B)	NS	NS

Table (9): Sucrose% of sugarcane at harvest, as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons

Treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100cm	120 m	Mean	80 cm	100 m	120cm	Mean
Garlon	17.88	18.40	17.64	17.97	18.06	18.33	18.12	18.17
Brominal	17.93	18.41	17.71	18.01	18.23	18.63	18.18	18.35
Bazagran	17.82	18.11	17.62	17.85	18.02	18.18	17.97	18.06
Granstar	17.73	18.23	17.74	17.90	18.00	18.13	18.03	18.05
Garlon and hand hoeing once	18.37	18.49	18.07	18.31	18.47	18.82	18.58	18.62
Brominal and hand hoeing once	18.39	18.54	18.17	18.37	18.53	18.02	18.55	18.70
Bazagran and hand hoeing once	18.06	18.37	17.79	18.07	18.29	18.56	18.18	18.34
Granstar and hand hoeing once	17.91	18.44	17.79	18.05	18.28	18.23	18.02	18.18
Hand hoeing three times	18.11	18.52	18.29	18.31	18.85	18.93	18.70	18.83
Untreated (control)	13.94	13.94	13.61	13.83	13.98	14.38	13.90	14.09
Mean	17.61	17.95	17.44		17.87	18.12	17.82	

LSD at 0.05 level for:

Row spacing (A)	0.16	0.11
Weeding treatments (B)	0.20	0.24
(A) x (B)	NS	NS

Table (10): Juice purity % of sugarcane at harvest, as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons

Treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100cm	120 m	Mean	80 cm	100cm	120cm	Mean
Garlon	83.99	84.65	83.21	83.95	83.93	84.30	84.43	84.22
Brominal	84.00	84.62	83.19	83.94	84.08	85.30	84.63	84.67
Bazagran	83.90	83.63	83.19	83.57	84.28	84.50	84.77	84.52
Granstar	83.78	84.73	84.06	84.19	84.52	84.65	84.72	84.63
Garlon and hand hoeing once	84.93	84.63	84.00	84.52	84.16	85.17	85.47	84.93
Brominal and hand hoeing once	84.86	84.46	84.34	84.55	84.36	85.43	85.08	84.96
Bazagran and hand hoeing once	84.33	84.31	83.21	83.95	84.59	85.49	84.50	84.86
Granstar and hand hoeing once	83.94	84.94	83.67	84.19	84.99	84.67	84.44	84.70
Hand hoeing three times	83.25	84.25	85.02	84.17	84.97	84.83	85.52	85.11
Untreated (control)	83.21	82.69	81.11	82.34	81.86	83.72	82.32	82.64
Mean	84.02	84.29	83.50		84.17	84.81	84.59	

LSD at 0.05 level for:

Row spacing (A)	0.45	0.43
Weeding treatments (B)	0.71	0.89
(A) x (B)	NS	NS

and 3.76 ton of canes/fed higher than that obtained by planting it in rows spaced at 100 and 120 cm, in the 1st season, respectively corresponding to 1.45 and 4.03 ton/fed, in the 2nd one. These results could be attributed to the increase in number of millable canes/fed as row spacing decreased (Table 7). These results are in agreement with those reported by El-Shafai and Ismail (2006) and Ahmed and Khaled (2008). Meanwhile, insignificant variance in cane yield/fed was found between 80 and 100-cm row spacing, in the 1st season.

The results pointed to a significant response of cane yield/fed due to the applied weed control treatments in the 1st and 2nd seasons. In the 1st one, controlling weeds with Garlon, Brominal, Bazagran and Granstar alone increased cane yield by 6.32, 5.77, 4.53 and 3.64 tons/fed, successively, compared with the unweeded plots. Meantime, the addition of one hand hoeing to each of the used herbicides, in the same order, raised the productivity of one feddan to 8.60, 9.76, 6.54 and 7.16 tons of canes. Moreover, hoeing weeds manually three times eradicated weeds to a large extent and resulted in getting the highest increase in cane yield (10.96 tons/fed), compared to the control, which produced the lowest cane yield/fed. Similar results were observed in the 2nd season. These results manifested the importance of hand hoeing as an effective means in getting rid of weeds that compete with sugarcane plants. These results are in line with those given by Singh *et al.* (2001), Attalla and Sogheir (2003), Saini *et al.* (2003) and Fakkar *et al.* (2009).

The interactions among row spacings and weed control treatments had insignificant effect on cane yield in both seasons.

3.2.3.2. Sugar yield

Data in Table (13) indicate that sugar yield was significantly influenced by row spacing in the 1st and 2nd seasons. In the 1st one, it was found that planting sugarcane in rows spaced at 80 and 100-cm apart increased sugar yield by 0.50 and 0.56 ton/fed, compared with that grown in rows of 120 cm, respectively, corresponding to 0.44 and 0.40 ton sugar/fed, in the 2nd season. Meantime, the difference between 80 and 100 cm in their effect on sugar yield was insignificant in both seasons. These results are in agreement with those reported by El-Shafai and Ismail (2006) and Ahmed and Khaled (2008). The results exhibited a significant effect on sugar yield due to the used weed control treatments in both seasons. In the 1st one, the single application of Garlon, Brominal, Bazagran and Granstar resulted in 2.03, 1.98

, 1.76 and 1.72 ton of sugar/fed higher than the unweeded plots, respectively. Moreover, combining each of the used herbicides with one hand hoeing following its application recorded 1.44, 2.59, 2.08 and 2.17 tons of sugar/fed, in the same respect. Based on the obtained results of growth, quality and cane yield presented in the previous Tables, practicing three hand hoeings to control weeds resulted in the production of the highest increase in sugar yield (2.68 tons/fed) compared to the control, which produced the lowest sugar yield/fed. Similar trend was recorded in the 2nd season. These results are in agreement with those found by Ali *et al.* (1986) and Fakkar *et al.* (2009).

Sugar yield was insignificantly affected by the interactions among row spacings and weed control treatments in both seasons.

3.3. Economic evaluation

Data in Table(14) show that the average total cost was L.E. 7142 fed⁻¹ for fixed cost (land rent, seed bed preparation, planting, post planting practices, *i.e.* fertilization, irrigation, insect control and harvesting) in 2007/08 and 2008/09 seasons. The average variable cost was L.E. 180, 120, 90, 80 and 40 fed⁻¹ for weed control by one hand hoeing, Garlon, Brominal, Bazagran and Granstar, respectively. The price of one ton of canes was L.E 234.5 in both seasons. The results cleared that the average net return was the highest in case of growing sugarcane in rows spaced at 80 cm (L.E. 5553.83), which attained L.E. 241.53 and 1113.38 higher than those gained when sugarcane was planted in rows of 100 and 120-cm apart.

As for the net income resulted from the application of the ten weed control treatments, the results indicated that the controlling weeds by Brominal herbicides + hand hoeing once (L.E. 5835.79), which was approximately equal to manual hoeing three times (L.E. 5833.12), while Garlon herbicide + hand hoeing once ranked the third (L.E. 5518.53). The lowest net income was recorded when weeds left to grow without any control whether sugarcane was grown at any of the three row spacing.

Concerning the profitability corresponded to the studied factors, data in Table (14) manifest that decreasing row width from 120 to 100 and 80 cm led to an increase in profitability %.

Meantime, the highest profitability % (80.83) was recorded by Brominal herbicides + hand hoeing once followed by three manual hoeings. However, unweeding (control) resulted in the lowest profitability (55.60%) compared with the other weed control treatments.

Table (11): Sugar recovery % of sugarcane at harvest, as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons

Treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100cm	120cm	Mean	80 cm	100 m	120 m	Mean
Garlon	11.24	11.64	10.99	11.29	11.34	11.55	11.44	11.44
Brominal	11.27	11.64	11.03	11.31	11.46	11.87	11.51	11.62
Bazagran	11.20	11.33	10.98	11.17	11.36	11.49	11.41	11.42
Granstar	11.12	11.56	11.17	11.28	11.39	11.48	11.44	11.44
Garlon and hand hoeing once	11.67	11.69	11.35	11.57	11.61	11.96	11.88	11.82
Brominal and hand hoeing once	11.67	11.70	11.47	11.61	11.67	12.12	11.80	11.86
Bazagran and hand hoeing once	11.40	11.58	11.08	11.35	11.57	11.86	11.49	11.64
Granstar and hand hoeing once	11.25	11.75	11.14	11.38	11.62	11.55	11.39	11.52
Hand hoeing three times	11.26	11.65	11.64	11.52	11.95	11.98	11.95	11.96
Untreated (control)	8.82	8.77	8.29	8.63	8.69	9.15	8.70	8.85
Mean	11.09	11.33	10.91		11.27	11.50	11.30	

LSD at 0.05 level for:

Row spacing (A)

0.17

0.13

Weeding treatments (B)

0.19

0.25

(A) x (B)

NS

NS

Table (12): Cane yield (ton/fed) at harvest, as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons

Treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 cm	100 cm	120 cm	Mean	80 cm	100 cm	120 cm	Mean
Garlon	53.39	53.65	50.03	52.36	56.16	54.80	50.97	53.98
Brominal	53.77	52.43	49.23	51.81	54.30	52.61	49.92	52.28
Bazagran	52.62	51.75	47.35	50.57	53.14	51.12	49.08	51.11
Granstar	51.18	50.17	47.69	49.68	51.36	50.43	48.34	50.05
Garlon and hand hoeing once	56.56	54.86	52.50	54.64	56.69	54.44	51.63	54.26
Brominal and hand hoeing once	56.54	56.66	54.22	55.80	56.50	56.58	53.57	55.55
Bazagran and hand hoeing once	54.51	53.69	49.55	52.58	56.27	54.58	51.29	54.05
Granstar and hand hoeing once	55.37	53.59	50.63	53.20	56.52	53.05	50.12	53.23
Hand hoeing three times	57.35	58.73	54.92	57.00	57.25	54.42	55.20	56.63
Untreated (control)	45.97	45.61	43.53	46.04	47.39	46.05	45.13	46.19
Mean	53.72	53.11	49.96		54.56	53.11	50.53	

LSD at 0.05 level for:

Row spacing (A)

0.95

0.50

Weeding treatments (B)

0.96

1.08

(A) x (B)

NS

NS

Table (13): Sugar yield (ton/fed), as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons.

Treatments	2007/2008 season				2008/2009 season			
	Row spacing				Row spacing			
	80 Cm	100 cm	120 cm	Mean	80 cm	100 cm	120 cm	Mean
Garlon	6.00	6.25	5.50	5.92	6.37	6.33	5.83	6.18
Brominal	6.06	6.11	5.43	5.87	6.22	6.25	5.75	6.07
Bazagran	5.89	5.86	5.20	5.65	6.04	5.88	5.60	5.84
Granstar	5.69	5.80	5.33	5.61	5.85	5.79	5.53	5.72
Garlon and hand hoeing once	6.60	6.42	5.96	5.33	6.58	6.51	6.14	6.41
Brominal and hand hoeing once	6.60	6.63	6.22	6.48	6.60	6.86	6.32	6.59
Bazagran and hand hoeing once	6.21	6.22	5.49	5.97	6.51	6.47	5.89	6.29
Granstar and hand hoeing once	6.23	6.29	5.64	6.06	6.57	6.13	5.71	6.13
Hand hoeing three times	6.46	6.84	6.39	6.57	6.84	6.88	6.60	6.77
Untreated (control)	4.06	4.00	3.61	3.89	4.12	4.21	3.93	4.09
Mean	5.98	6.04	5.48		6.17	6.13	5.73	

LSD at 0.05 level for:

Row spacing (A)

0.09

0.14

Weeding treatments (B)

0.18

0.14

(A) x (B)

NS

NS

Table (14): Gross income, total costs, net income (by Egyptian pound) and profitability as affected by row spacing, weed control treatments and their interactions in 2007/2008 and 2008/2009 seasons

Row spacing	Weed control	Gross income L.E		Mean	Total cost L.E	Net income L.E	Profitability (%)
		2007/2008	2008/2009				
80 cm	Garlon	12519.96	13169.52	12844.74	7070	5774.74	81.68
	Brominal	12609.07	12733.35	12671.21	7040	5631.21	79.98
	Bazagran	12339.39	12461.33	12400.36	7030	5370.36	76.39
	Granstar	12001.71	12043.92	12022.82	6990	5032.82	72.00
	Garlon and hand hoeing once	13263.32	13293.81	13278.56	7250	6028.56	83.15
	Brominal and hand hoeing once	13258.63	13249.25	13253.94	7220	6033.94	83.57
	Bazagran and hand hoeing once	12782.60	13195.32	12988.96	7210	5778.96	80.15
	Granstar and hand hoeing once	12984.27	13253.94	13119.10	7170	5949.10	82.97
	Hand hoeing three times	13448.58	13425.13	13436.85	7490	5946.85	79.40
	Untreated (control)	10779.97	11112.96	10946.46	6950	3996.46	57.50
Mean		12597.34	12794.32	12695.83	7142	5553.83	77.76
100 cm	Garlon	12580.93	12850.60	12715.76	7070	5645.76	79.85
	Brominal	12294.84	12337.05	12315.94	7040	5275.94	74.94
	Bazagran	12135.38	11987.64	12061.51	7030	5031.51	71.57
	Granstar	11764.87	11825.84	11795.35	6990	4805.35	68.75
	Garlon and hand hoeing once	12864.67	12766.18	12815.43	7250	5565.43	76.76
	Brominal and hand hoeing once	13286.77	13268.01	13277.39	7220	6057.39	83.90
	Bazagran and hand hoeing once	12590.31	12799.01	12694.66	7210	5484.66	76.07
	Granstar and hand hoeing once	12566.86	12440.23	12503.54	7170	5333.54	74.39
	Hand hoeing three times	13772.19	12761.49	13266.84	7490	5776.84	77.127
	Untreated (control)	10695.55	10798.73	10747.14	6950	3797.14	54.64
Mean		12454.30	12454.30	12454.30	7142	5312.30	74.38
120 cm	Garlon	11732.04	11952.47	11842.25	7070	4772.25	67.50
	Brominal	11544.44	11706.24	11625.34	7040	4585.34	65.13
	Bazagran	11103.58	11509.26	11306.42	7030	4276.42	60.84
	Granstar	11183.31	11335.73	11259.52	6990	4269.52	61.08
	Garlon and hand hoeing once	12311.25	12107.24	12209.24	7250	4959.24	68.40
	Brominal and hand hoeing once	12714.59	12562.17	12638.38	7220	5418.38	75.05
	Bazagran and hand hoeing once	11619.48	12027.51	11823.49	7210	4613.49	63.99
	Granstar and hand hoeing once	11872.74	11753.14	11812.94	7170	4642.94	64.76
	Hand hoeing three times	12878.74	12944.40	12911.57	7490	5421.57	72.38
	Untreated (control)	10207.79	10582.99	10395.39	6950	3445.39	49.57
Mean		11715.62	11849.29	11782.45	7142	4640.45	64.97
Mean of weed control	Garlon	12278.42	12658.31	12468.37	7070	5398.37	76.35
	Brominal	12149.45	12259.66	12204.55	7040	5164.55	73.36
	Bazagran	11858.67	11985.30	11921.98	7030	4891.98	69.59
	Granstar	11649.96	11736.73	11693.34	6990	4703.34	67.29
	Garlon and hand hoeing once	12813.08	12723.97	12768.53	7250	5518.53	76.12
	Brominal and hand hoeing once	13085.10	13026.48	13055.79	7220	5835.79	80.83
	Bazagran and hand hoeing once	12330.01	12674.73	12502.37	7210	5292.37	73.40
	Granstar and hand hoeing once	12475.40	12482.44	12478.92	7170	5308.92	74.04
	Hand hoeing three times	13366.50	13279.74	13323.12	7490	5833.12	77.88
	Untreated (control)	10796.38	10831.56	10813.97	6950	3863.97	55.60

In conclusion, growing sugarcane, under conditions of the present work, in rows spaced at 80 or 100 cm and controlling accompanied weeds by manual hoeing three times 25, 45 and 65 DAP, Brominal + hand hoeing once and/or Garlon + hand hoeing once, can be recommended for getting the highest cane and sugar yields/fed. Meanwhile, economic evaluation of the studied factors showed that planting sugarcane in rows of 80-cm apart, as well as controlling weeds by applying Brominal herbicide + hand hoeing once or manual hoeing three times gave the highest values of net income and profitability%.

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