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Dipika G Chaudhari
Ph.D. Scholar, Department of
Agronomy, N.M. College of
Agriculture, Navsari Agricultural
University, Navsari, Gujarat, India

Dr. DD Patel
Principal, College of Agriculture,
Navsari Agricultural University,
Bharuch, Gujarat, India

Dr. TU Patel
Associate Professor, Department of
Agronomy, College of Agriculture,
Navsari Agricultural University,
Bharuch, Gujarat, India

Dr. HM Patel
Professor, Polytechnic in
Horticulture, ASPEE College of
Horticulture Navsari Agricultural
University, Navsari, Gujarat, India

GM Imran
Ph.D. Scholar, Department of
Agronomy, N.M. College of
Agriculture, Navsari Agricultural
University, Navsari, Gujarat, India

Corresponding Author:
Dipika G Chaudhari
Ph.D. Scholar, Department of
Agronomy, N.M. College of
Agriculture, Navsari Agricultural
University, Navsari, Gujarat, India

Response of single eye-budded settling sugarcane to different spacing and weed management practices under south Gujarat conditions

Dipika G Chaudhari, DD Patel, TU Patel, HM Patel and GM Imran

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Abstract

A field experiment was conducted during *rabi* seasons of 2023–24 and 2024–25 at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, to identify suitable spacing and weed management practices for single eye budded settling planted sugarcane under south Gujarat conditions. The experiment was laid out in a Split Plot Design with four spacing treatments viz., 120 × 45 cm, 150 × 30 cm, 100 × 60 cm and 120 × 60 cm as main plots and seven weed management practices as sub-plots. The spacing of 150 × 30 cm recorded the highest single cane weight (1.32kg), number of millable canes (99187/ha), highest dry matter production (32196 kg/ha), and cane yield (107.61 t/ha) in pooled analysis. Among weed management practices, weed-free treatment through Hand weeding at interval of 30 days up to 150 DAP recorded maximum plant height at harvest (307.63cm), single cane weight (1.25 kg), number of millable canes (90025/ha) and total dry matter accumulation in sugarcane plant (33453 kg/ha) and cane yield (112.14t/ha) in pooled analysis and remained statistically at par with treatment interculturing followed by hand weeding at 30 and 60 DAP or hand weeding at 30 DAP followed by application of 2,4-D + metribuzin at 60 DAP. Unweeded control recorded the poorest performance. The study indicated that spacing of 150 × 30 cm combined with effective weed management can substantially improve productivity of single eye budded settling planted sugarcane under South Gujarat conditions.

Keywords: Sugarcane, spacing, weed management, split plot design, single eye budded settling planted, cane yield

Introduction

Sugarcane (*Saccharum officinarum* L.) is a crucial industrial cash crop primarily cultivated in tropical and subtropical areas worldwide. It is not only the main source of sugar but also serves as an important raw material for producing jaggery, ethanol, biodegradable materials, and animal feed, making a significant contribution to the agricultural economy (Mishra *et al.*, 2021) ^[11]. India ranks as the second-largest producer of sugarcane globally, following Brazil, with a cultivation area of 55.07 lakh hectares and a production of 4399.30 lakh tonnes in the 2024–25 season (Anonymous, 2025) ^[1]. In Gujarat, sugarcane is predominantly grown in the districts of Junagadh, Vadodara, Narmada, Bharuch, Tapi, Surat, Navsari, and Valsad. Traditionally, sugarcane is planted using 2 or 3 budded setts, but the practice of utilizing single eye budded settlings has emerged as a more efficient method. In contrast to the traditional planting method that needs 7.5–8.0 t seed cane/ha, this approach guarantees better use of planting materials and enhanced nursery management (Sachdeva *et al.*, 2021) ^[19]. Nonetheless, the successful implementation of this method is heavily reliant on suitable agronomic practices, especially optimal spacing and efficient weed control.

Plant spacing is a key factor influencing crop population, canopy development, light interception, nutrient uptake and moisture utilization. Optimum spacing facilitates efficient resource use and minimizes inter-plant competition, resulting in improved growth and yield. In single eye budded settling planted sugarcane, spacing assumes greater importance due to its distinct crop establishment pattern (Thorave *et al.*, 2020; Virdia *et al.*, 2022) ^[24, 25]. Spacing also affects weed emergence and competition. Optimum crop geometry promotes faster canopy closure and suppresses weeds through shading (Patel *et al.*, 2014) ^[14].

Weeds are significant factors hindering sugarcane yield due to the crop's slow early development, broad row spacing, and extended growth duration. They compete with sugarcane for essential resources such as nutrients, moisture, light, and space, resulting in yield losses between 38 and 76 percent (Singh *et al.*, 2018) ^[21]. The critical timeframe for crop-weed competition typically occurs between 60 and 120 days after planting (DAP) for spring cane, and at 150 DAP for autumn cane (Rohitashav *et al.*, 2011) ^[18]. More broadly, the period from 90 to 120 DAP is regarded as critical (Srivastava *et al.*, 2005) ^[22]. Effective management of weeds during this timeframe is necessary to achieve optimal cane yields (Rana *et al.*, 2004) ^[17]. Farmers in the South Gujarat area view sugarcane as a crucial cash crop for their economic sustenance. However, no adequate information is so far available on inter and intra row spacing and proper weed control strategies in sugarcane by using single eye bud settling (Virdia *et al.*, 2023) ^[26]. Therefore, identification of suitable

spacing combined with efficient weed management practices is essential for sugarcane cultivation in South Gujarat conditions.

Materials and Methods

A field experiment was carried out at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India during *rabi* season of two consecutive years 2023-24 and 2024-25. Geographically, site is situated at 20° 57' North latitude, 72° 54' East longitude with an elevation of 10 meters of above the mean sea level. The soil of experimental site was deep black soil with low in organic carbon (0.36% and 0.34%) and available nitrogen (243.65 and 250.60 kg/ha), while medium in available phosphorus (30.68 and 32.14 kg/ha) and high in available potassium (338.36 and 348.62 kg/ha) during the two seasons, respectively. Experiment was laid out in Split Plot Design with four spacings as main plot and seven weed control measures as sub plots (Table 1).

Table 1: Treatment details of the experiment

Main plot (Spacings)	
S ₁	120 × 45 cm
S ₂	150 × 30 cm
S ₃	100 × 60 cm
S ₄	120 × 60 cm
Sub plot (Weed management)	
W ₁	Unweeded (Control)
W ₂	Weed free (Hand weeding at interval of 30 days up to 150 DAP)
W ₃	Interculturing followed by hand weeding at 30 and 60 DAP
W ₄	Sugarcane with dhaincha as smothering crop (cutdown at 50% flowering and mulch)
W ₅	Hand weeding at 30 DAP + application of 2,4-D@ 1.5kg/ha + Metribuzine @1.0 kg/ha (Post emergence) at 60 DAP
W ₆	Hand weeding at 30 DAP + application of Readymix- Mesotrione 2.27% w/w + Atrazine 22.7% w/w SC@ 875 g/ha at 60 DAP
W ₇	Hand weeding at 30 DAP + application of Readymix- Sulfentrazone 28% + Clomazone 30% wp @ 700 + 750 g/ha at 60 DAP

Settlings were grown using the single eye buds of sugarcane variety CoN 15071(Divyashi). After 25 days of sowing, emerged settlings were transplanted to the main field. Recommended dose of fertilizers (250 -125 -125 kg N-P₂O₅-K₂O/ha) was given in the form of urea, single super phosphate and muriate of potash. Weed management was done by hand weeding, intercropping and applying herbicides as per treatments, except in the unweeded control plot. Additionally, final earthing up was carried out at 135 to 140 days after transplanting of crop. In W₄, dhaincha was cut down at 55 DAS and kept as mulch in the same place for smothering the weeds and incorporated in the soil at final earthing up. Observations were recorded on plant height, single cane weight, number of millable canes per hectare, drymatter production and cane yield at harvest. Recorded data was subjected to statistical analysis of variance as per procedure of Split Plot Design as described by Panse and Sukhatme (1967) ^[13].

Results and Discussion

Plant height

The data presented in Table 2 revealed that plant height of sugarcane at harvest was not significantly varied by different spacings. This suggests that early vegetative growth of sugarcane is less sensitive to row and plant geometry, possibly due to sufficient availability of resources during initial growth stages. Whereas weed management treatments showed significant differences during both years and in pooled data. The weed-free treatment (W₂: Hand weeding at 30-day intervals up to 150 DAP) recorded the maximum plant height (303.72 cm,

311.54 cm and 307.63 cm during both the years and in pooled data, respectively), which was statistically at par with W₃ (IC fb HW at 30 and 60 DAP) and W₅ (HW at 30 DAP + application of 2,4-D @ 1.5 kg/ha + Metribuzine @1.0 kg/ha at 60 DAP) recorded comparatively higher plant height. The unweeded control (W₁) recorded the lowest plant height (269.31, 272.60 and 270.96 cm, during both the years and in pooled analysis, respectively). The interaction effect between spacing and weed management (S × W) was non-significant. Significant improvement in plant height under weed-free treatment (W₂) and interculturing combined with hand weeding (W₃) indicates the importance of minimizing crop-weed competition during the early growth phase. Effective weed control ensured better availability of nutrients, moisture and light, resulted in enhanced plant height (Mansuri *et al.*, 2014 and Yadav *et al.*, 2020) ^[10, 27]. The superiority of integrated weed management practices such as W₅ over the unweeded control highlights the role of combining manual and chemical methods for effective weed suppression. The use of herbicides like 2,4-D and metribuzin in combination with hand weeding likely reduced weed density and improved crop growth as also reported by Kumar *et al.* (2021) ^[8] and Jaiswal *et al.* (2024) ^[6] in sugarcane.

Single cane weight

Single cane weight was significantly influenced by spacing during both years as well as in pooled analysis. The highest cane weight was recorded under S₂: 150 cm × 30 cm (1.31,1.33 and 1.32 kg during both the years and in pooled analysis,

respectively). This was followed by S_1 : 120 cm $\times$ 45 cm (1.25, 1.25 and 1.25kg), S_3 and S_4 (Table 3).

Weed management practices significantly influenced single cane weight. The highest cane weight was recorded under weed-free treatment with hand weeding at 30-day intervals up to 150 DAP (W_2) with values of 1.26, 1.23 and 1.24 kg, which was at par with all other weed management treatments. In contrast unweeded control (W_1) recorded significantly lower single cane weight (0.92, 0.92 and 0.92 kg).

Number of Millable Canes/hectare

The data presented in Table 4 clearly indicated that NMC was significantly influenced by spacing during 2023–24, 2024–25 and in pooled analysis. Among the spacing treatments, S_2 (150 cm $\times$ 30 cm) recorded the highest number of millable canes/ha (98558, 99816 and 99187/ha during both the individual years and in pooled analysis, respectively) which was significantly superior to all other treatments. S_1 and S_3 were also found significantly higher than S_4 . The lowest number of millable canes was observed under S_4 : 120 cm $\times$ 60 cm (62323, 62870 and 62596/ha during the both the year and pooled data).

Weed management practices exerted a significant effect on NMC across both years and pooled data. The weed-free treatment W_2 (hand weeding at 30-day intervals up to 150 DAP) recorded the maximum number of millable canes/ha (89404, 90647 and 90025 during the year 2023–24, 2024–25 and in pooled data respectively), which was statistically at par with W_3 (87855, 88589 and 88222/ha) and W_5 (86357, 86865 and 86611). The lowest number of millable canes/ha was recorded under unweeded control W_1 (55079, 57021 and 56050/ha), which was significantly inferior to all treatments.

Weed management practices played a crucial role in determining NMC. The highest NMC under weed-free treatment (W_2) may be due to effective and continuous removal of weeds, which minimized competition for nutrients, moisture and light throughout the crop growth period. This facilitated better tillering and survival of shoots, ultimately increasing the number of millable canes. Similar results were reported by Kumar *et al.* (2014) [9], who found that weed-free conditions significantly enhanced cane population.

The improved performance of W_3 (Interculturing followed by hand weeding) indicates weed control during early growth stages, which is critical for tiller formation and survival. Early removal of weeds reduces competition during the formative phase of the crop, leading to higher cane population. These findings are supported by Ballayan *et al.* (2015), who emphasized the importance of early weed management in improving sugarcane growth parameters including cane population.

The lower NMC under unweeded control (W_1) clearly reflects the negative impact of prolonged weed competition, which suppresses tillering and increases mortality of shoots. This result is in agreement with Ramesha *et al.* (2018) [16], who reported significant reductions in millable cane number under weedy conditions.

Dry matter production

Sugarcane drymatter production was significantly influenced by spacing during both years as well as in pooled analysis. Among the treatments, 150 cm $\times$ 30 cm spacing (S_2) recorded

significantly higher drymatter accumulation (31969, 32423 and 32196 kg/ha during the year 2023–24, 2024–25 and pooled data, respectively). This was followed by 120 cm $\times$ 45 cm (S_1) (28761, 28927 and 28843 kg/ha), which remained at par with 100 cm $\times$ 60 cm (S_3) (28505, 28559 and 28531 kg/ha) and S_4 : 120 cm $\times$ 60 cm (25652, 25928 and 25790 kg/ha across both years and pooled analysis). The significantly higher dry matter accumulation under 150 cm $\times$ 30 cm spacing (S_2) can be attributed to an optimum canopy architecture and efficient radiation interception. This spacing ensured better light penetration and distribution within the canopy, which enhanced photosynthetic activity and biomass production. Similar findings were reported by Swapna *et al.* (2020) [23] with 150 cm row spacing (Table 3).

In case of different weed management strategies, hand weeding at 30-day intervals up to 150 DAP (W_2) recorded higher drymatter (33319, 33588 and 33453kg/ha during both the years and in pooled analysis, respectively) and it was statistically at par with interculturing followed by hand weeding at 30 and 60 DAP (W_3) (32614, 33088 and 32851 kg/ha during both the years and in pooled analysis, respectively) and W_5 (hand weeding at 30 DAP + 2,4-D + Metribuzin application at 60 DAP) (32183, 32540 and 32361 kg/ha during both the years and in pooled analysis, respectively). The lowest total dry matter accumulation was recorded under unweeded control (W_1) (15318, 15334 and 15326 kg/ha), which was significantly inferior to all other treatments during both the years and in pooled data, respectively.

The higher dry matter accumulation under weed free and its parity with W_3 and W_5 may be attributed to effective weed suppression during the critical crop-weed competition period, resulting in greater availability of nutrients, moisture, light and space for crop growth. This promoted better canopy development and photosynthetic activity, leading to increased biomass production. This was earlier confirmed by Fakkar *et al.* (2009) [4], Singh and Kumar (2013) [20], Ballyan *et al.* (2015) [2] and Ombase *et al.* (2019) [12]. In contrast, the lowest dry matter accumulation under unweeded control (W_1) was due to severe weed competition throughout the crop growth period. The interaction between spacing and weed management ($S \times W$) was nonsignificant during both years and pooled analysis.

Cane yield

Among the spacings, S_2 : 150 $\times$ 30 cm recorded significantly higher cane yield (106.64, 108.58 and 107.61 t/ha) during both the year and in pooled data analysis, respectively). Also, S_1 : 120 $\times$ 45 cm (96.12, 97.01 and 96.57 t/ha, respectively) and S_3 : 100 $\times$ 60 cm (95.30, 95.85 and 95.58 t/ha) obtained significantly higher cane yield than S_4 : 120 $\times$ 60 cm (85.66, 86.83 and 86.24 t/ha during both the year and in pooled data analysis, respectively) (Table 4). Higher yield advantage under 150 cm $\times$ 30 cm aligns with other reports by Ghaffar *et al.* (2012) [5], Chaudhari *et al.* (2021) [3] and Virdia *et al.* (2023) [26] where it was observed that wider inter row and closer intra row spacing increased plant density and yield due to better canopy architecture and resource utilization. The lowest yield recorded under the 120 $\times$ 60 cm spacing (S_4) suggested that excessively intra row spacing reduced effective stand and light interception, leading to lower productivity.

Table 2: Effect of spacing and weed management on plant height (cm) of sugarcane at harvest

Treatments		2023-24	2024-25	Pooled
Spacing (S)				
S ₁	120 × 45 cm	281.40	286.60	284.00
S ₂	150 × 30 cm	274.42	279.62	277.02
S ₃	100 × 60 cm	294.90	300.68	297.79
S ₄	120 × 60 cm	305.72	311.38	308.55
SEm ±		6.44	6.56	4.59
CD (P ≤ 0.05)		NS	NS	NS
CV (%)		10.21	10.21	10.21
Weed management (W)				
W ₁	Unweeded (Control)	269.31	282.60	270.96
W ₂	Weed free (Hand weeding at interval of 30 days up to 150 DAP)	303.72	311.54	307.63
W ₃	Interculturing followed by hand weeding at 30 and 60 DAP	300.00	306.92	303.47
W ₄	Sugarcane with dhaincha as smothering crop (cutdown at 50% flowering and mulch)	282.16	286.44	284.30
W ₅	Hand weeding at 30 DAP + application of 2,4-D@ 1.5kg/ha + Metribuzine @1.0 kg/ha (Post emergence) at 60 DAP	293.97	299.58	296.78
W ₆	Hand weeding at 30 DAP + application of Readymix- Mesotrione 2.27% w/w + Atrazine 22.7% w/w SC@ 875 g/ha at 60 DAP	288.62	294.25	291.44
W ₇	Hand weeding at 30 DAP + application of Readymix- Sulfentrazone 28% + Clomazone 30% wp @ 700 + 750 g/ha at 60 DAP	285.97	290.63	288.30
SEm ±		6.69	7.25	4.93
CD (P ≤ 0.05)		19.03	20.61	13.84
CV (%)		8.02	8.52	8.28
Interaction effect (S x W)				
SEm ±		13.38	14.50	9.86
CD (P ≤ 0.05)		NS	NS	NS

Table 3: Effect of spacing and weed management on single cane weight (kg) of sugarcane at harvest

Treatments		2023-24	2024-25	Pooled
Spacing (S)				
S ₁	120 × 45 cm	1.250	1.257	1.25
S ₂	150 × 30 cm	1.319	1.330	1.32
S ₃	100 × 60 cm	1.160	1.122	1.14
S ₄	120 × 60 cm	1.060	1.012	1.04
SEm ±		0.02	0.02	0.01
CD (P ≤ 0.05)		0.07	0.07	0.04
CV (%)		7.88	7.50	7.70
Weed management (W)				
W ₁	Unweeded (Control)	0.923	0.921	0.92
W ₂	Weed free (Hand weeding at interval of 30 days up to 150 DAP)	1.260	1.236	1.25
W ₃	Interculturing followed by hand weeding at 30 and 60 DAP	1.253	1.233	1.24
W ₄	Sugarcane with dhaincha as smothering crop (cutdown at 50% flowering and mulch)	1.226	1.216	1.22
W ₅	Hand weeding at 30 DAP + application of 2,4-D@ 1.5kg/ha + Metribuzine @1.0 kg/ha (Post emergence) at 60 DAP	1.246	1.225	1.24
W ₆	Hand weeding at 30 DAP + application of Readymix- Mesotrione 2.27% w/w + Atrazine 22.7% w/w SC@ 875 g/ha at 60 DAP	1.234	1.212	1.22
W ₇	Hand weeding at 30 DAP + application of Readymix- Sulfentrazone 28% + Clomazone 30% wp @ 700 + 750 g/ha at 60 DAP	1.238	1.218	1.23
SEm ±		0.02	0.02	0.017
CD (P ≤ 0.05)		0.07	0.07	0.04
CV (%)		7.10	7.10	7.10
Interaction effect (S x W)				
SEm ±		0.05	0.05	0.03
CD (P ≤ 0.05)		NS	NS	NS

Table 4: Effect of spacing and weed management on number of millable canes per hectare of sugarcane at harvest

Treatments		2023-24	2024-25	Pooled
Spacing (S)				
S ₁	120 × 45 cm	81502	82335	81918
S ₂	150 × 30 cm	98558	99816	99187
S ₃	100 × 60 cm	74998	75747	75373
S ₄	120 × 60 cm	62323	62870	62596
SEm ±		1367	1508	1438
CD (P ≤ 0.05)		4733	5219	4972
CV (%)		7.90	8.62	8.27
Weed management (W)				
W ₁	Unweeded (Control)	55079	57021	56050

W ₂	Weed free (Hand weeding at interval of 30 days up to 150 DAP)	89404	90647	90025
W ₃	Interculturing followed by hand weeding at 30 and 60 DAP	87855	88589	88222
W ₄	Sugarcane with dhaincha as smothering crop (cutdown at 50% flowering and mulch)	68414	69530	68972
W ₅	Hand weeding at 30 DAP + application of 2,4-D@ 1.5kg/ha + Metribuzine @1.0 kg/ha (Post emergence) at 60 DAP	86357	86865	86611
W ₆	Hand weeding at 30 DAP + application of Readymix- Mesotrione 2.27% w/w + Atrazine 22.7% w/w SC@ 875 g/ha at 60 DAP	83617	83857	83737
W ₇	Hand weeding at 30 DAP + application of Readymix- Sulfentrazone 28% + Clomazone 30% wp @ 700 + 750 g/ha at 60 DAP	84689	84835	84762
SEm ±		1743	1906	1820
CD (P ≤ 0.05)		4957	5404	5181
CV (%)		7.61	8.21	7.92
Interaction effect (S x W)				
SEm ±		3486	3801	2579
CD (P ≤ 0.05)		NS	NS	NS

Table 5: Effect of spacing and weed management on sugarcane drymatter production (kg/ha) at harvest

Treatments		2023-24	2024-25	Pooled
Spacing (S)				
S ₁	120 × 45 cm	28761	28927	28843
S ₂	150 × 30 cm	31969	32423	32196
S ₃	100 × 60 cm	28505	28559	28531
S ₄	120 × 60 cm	25652	25928	25790
SEm ±		448	469	457
CD (P ≤ 0.05)		1552	1624	1584
CV (%)		7.16	7.43	7.29
Weed management (W)				
W ₁	Unweeded (Control)	15318	15334	15326
W ₂	Weed free (Hand weeding at interval of 30 days up to 150 DAP)	33319	33588	33453
W ₃	Interculturing followed by hand weeding at 30 and 60 DAP	32614	33088	32851
W ₄	Sugarcane with dhaincha as smothering crop (cutdown at 50% flowering and mulch)	25560	25652	25606
W ₅	Hand weeding at 30 DAP + application of 2,4-D@ 1.5kg/ha + Metribuzine @1.0 kg/ha (Post emergence) at 60 DAP	32183	32540	32361
W ₆	Hand weeding at 30 DAP + application of Readymix- Mesotrione 2.27% w/w + Atrazine 22.7% w/w SC@ 875 g/ha at 60 DAP	30487	30527	30507
W ₇	Hand weeding at 30 DAP + application of Readymix- Sulfentrazone 28% + Clomazone 30% wp @ 700 + 750 g/ha at 60 DAP	31570	31986	31778
SEm ±		546	569	556
CD (P ≤ 0.05)		1554	1620	1585
CV (%)		6.60	6.82	6.71
Interaction effect (S x W)				
SEm ±		1093	1139	1115
CD (P ≤ 0.05)		NS	NS	NS

Table 6: Effect of spacing and weed management on sugarcane yield (t/ha)

Treatments		2023-24	2024-25	Pooled
Spacing (S)				
S ₁	120 × 45 cm	96.12	97.01	96.57
S ₂	150 × 30 cm	106.64	108.58	107.61
S ₃	100 × 60 cm	95.30	95.85	95.58
S ₄	120 × 60 cm	85.66	86.83	86.24
SEm ±		1.91	1.97	1.93
CD (P ≤ 0.05)		6.60	6.81	6.71
CV (%)		9.11	9.29	9.20
Weed management (W)				
W ₁	Unweeded (Control)	50.56	52.11	51.33
W ₂	Weed free (Hand weeding at interval of 30 days up to 150 DAP)	111.76	112.52	112.14
W ₃	Interculturing followed by hand weeding at 30 and 60 DAP	109.72	111.17	110.45
W ₄	Sugarcane with dhaincha as smothering crop (cutdown at 50% flowering and mulch)	85.34	86.34	85.84
W ₅	Hand weeding at 30 DAP + application of 2,4-D@ 1.5kg/ha + Metribuzine @1.0 kg/ha (Post emergence) at 60 DAP	107.50	108.20	107.91
W ₆	Hand weeding at 30 DAP + application of Readymix- Mesotrione 2.27% w/w + Atrazine 22.7% w/w SC@ 875 g/ha at 60 DAP	101.10	102.20	101.68
W ₇	Hand weeding at 30 DAP + application of Readymix- Sulfentrazone 28% + Clomazone 30% wp @ 700 + 750 g/ha at 60 DAP	105.40	106.82	106.14
SEm ±		2.48	2.57	2.52
CD (P ≤ 0.05)		7.06	7.32	7.16
CV (%)		8.97	9.18	9.08
Interaction effect (S x W)				
SEm ±		4.97	5.15	5.04
CD (P ≤ 0.05)		NS	NS	NS

Conclusion

Based on the results of the experiment under south Gujarat conditions for cultivation of single eye budded settling planted sugarcane, 150 × 30 cm proved superior by recording the highest dry matter production and cane yield, indicating better crop establishment, resource utilization and biomass accumulation. For effective weed management, hand weeding at 30 DAP followed by application of 2,4-D @ 1.5 kg/ha + metribuzin @ 1.0 kg/ha at 60 DAP or Readymix-Sulfentrazone 28% + Clomazone 30% wp @ 700 + 750 g/ha at 60 DAP can be recommended as a practical alternative to maintaining weed-free conditions throughout the crop growth period.

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