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Research Article

EFFECT OF VARIOUS FERTILITY LEVELS AND WEED MANAGEMENT PRACTICES ON GROWTH, YIELD POTENTIAL AND ECONOMICS OF SUGARCANE (*Saccharum officinarum* L.)

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Abstract: A field experiment was conducted during the year of 2016–17 and 2017–18 at research farm of Navsari agricultural University, Navsari to study the effect of NPK levels and weed management practices on of sugarcane (*Saccharum officinarum* L.). The crop fertilized with 125% RDF (F_3) being at par with 100 % RDF (F_2) resulted in the highest cane yield and number of millable canes than lower fertility level mainly because of remarkable improvement in individual cane, cane weight, cane girth, cane length, tillering and lower mortality. The dose of 125% RDF was found economically more sound, as it generated the highest gross realization (₹ 392423/ha) and net realization (₹ 277802/ha) with B:C ratio of 2.42. Among the weed-management practices, Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP (W_2) proved efficient in controlling the weed population and dry-matter production at all the growth stages, as evident by the highest weed control efficiency followed by treatment W_5. All the growth and yield attributes were witnessed higher under treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) and higher sugarcane equivalent yield (121.4 t/ha) was observed under the treatment W_5 (Pendimethalin 1.0 kg/ha as pre-emergence + Gram as an intercrop) followed by treatment W_2 (113.7 t/ha). The highest gross realization (₹ 425013/ha), net-realization (₹ 309579/ha) and B:C ratio (2.68) was obtained with the treatment W_5 (Pendimethalin 1.0 kg/ha as pre-emergence + gram as an intercrop) followed by treatment W_2 and W_6. While, the lowest gross realization (₹ 274363/ha), net realization (₹ 174416/ha) and B:C ratio (1.75) was obtained under W_1 (Weedy check) treatment.

Keywords: *Sugarcane, Cane yield, NPK levels, Weed management, Economics*

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Introduction

Sugarcane (*Saccharum officinarum* L.) has a great importance over the cash crops of India. However, its productivity in India is low compared with that in many other sugarcane growing countries of the world. Nitrogen, phosphorus and potassium account for bulk of essential nutrients, which many soils are deficient and need supplementation through organic and inorganic sources. Higher fertilizer doses proved to be superior within respect to growth and yield. Thus, to make the sugarcane cultivation more remunerative, there is a need to refine NPK recommendation up to the desired level. Due to slow germination and initial growth, wide row spacing, slow lateral spread, adequate supply of nutrients and moisture, long duration and diversity in weed population, sugarcane generally suffers from the tremendous weed problems. Among the factors for low productivity, negligence towards weed management is the most important, as the losses due to weeds range from 40% reduction in cane yield to total crop failure [1]. Large number of weeds flourish in sugarcane fields due to the slow initial growth of the crop, wide spacing between the crop rows, frequent and heavy irrigations, application of heavy doses of manures and fertilizers, and the warm and humid climate during a large part of the growing season. On the other hand, only application of herbicide is not proved so effective method. Similarly, alternative herbicides should be tested to minimize the chances of weed resurgence against commonly used herbicides having the same mode of action. Considering these facts, the present investigation was conducted to evaluate different fertility levels and weed-management practices in spring-planted sugarcane.

Materials and methods

A field experiment was conducted during 2016-17 and 2017-18 at the research farm of Navsari agricultural University, Navsari (20°57' N latitude, 72°54' E longitude) Gujarat. The soil was clay in texture, having organic carbon (0.38 and 0.42 %), medium in available nitrogen (236 and 242 kg/ha) and phosphorus (23.6 and 21.8 kg/ha), fairly rich in available potassium 152 (433 and 413 kg/ha) and slightly alkaline in reaction (pH 7.9 and 8.1) with normal electrical conductivity (0.36 and 0.38), respectively. Total eighteen treatment combinations consisting of three treatment of fertilizer levels F_1: 75% RDF (187.5-93.7-93.7 N:P_2O_5:K_2O kg/ha), F_2: 100% RDF (250-125-125 N:P_2O_5:K_2O kg/ha), F_3: 125% RDF (312.5-156.2-156.2 N:P_2O_5:K_2O kg/ha) and six treatments of weed management W_1: Weedy check, W_2: Three hand weedings at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP, W_3: Atrazine 2.0 kg/ha as a pre emergence + One HW and IC at 60 DAP, W_4: Metribuzin 1.5 kg/ha as pre emergence + One HW and IC at 60 DAP, W_5: Pendimethalin 1.0 kg/ha as pre emergence + Gram as an intercrop, W_6: Pendimethalin 1.0 kg/ha as pre emergence + Sunnhemp as green manure crop harvested and mulched it at 50-60 DAP and incorporated at final earthing up were evaluated in factorial randomized block design with three replications. A variety of sugarcane 'CoN-9072' was planted on 3rd and 20th December of the year 2016 and 2017, respectively on leveled soil by opening 15 cm deep furrow at 90 cm row spacing. Two eye budded setts obtained from sugarcane variety were used @ 50,000 per hectare. Two eye budded setts were planted in furrows after treating with 0.1 percent solution each of Emisan and Melathion for control of fungal and insect infestation.

All the recommended agronomic practices were followed throughout the cropping period. The crop was harvested on 11th and 25th December of the year 2017 and 2018, respectively. The required quantities of well decomposed FYM 10 t/ha were calculated for gross plot area and uniformly applied to all the experimental units before planting during both the years. The required quantity of urea, single super phosphate (SSP) and muriate of potash (MOP) for gross plot area were worked out as per treatment. The full quantity of SSP and MOP was applied as basal. Whereas, urea was applied in four splits as 15 percent N at the time of planting, 30 percent N at 45 days after planting, 20 percent N at 90 days after planting and 35 percent N before final earthing-up *i.e*. 150 days after planting fertilizers were manually applied uniformly in all the experimental units during both the years. All the herbicides were applied with the help of manually operated knapsack sprayer fitted with a flat fan nozzle using a volume spray of 600 liters water/ha. However, the intercrops *viz*., gram (cv. GJG-5) and sunnhemp were sown three days after the planting in between the two rows of sugarcane crop. Gram seeds were dibbled manually (two seeds at each spot) in the opened lines of treatment plots keeping the distance of 30 cm apart and 10 cm within the row using the seed rate of 60 kg per hectare. While the sunnhemp seeds were broadcasted between the row using a seed rate of 80 kg per hectare. Weed counts were taken by random placing an iron quadrate measuring 1.0 square meter area in each net plot at 45 and 90 days after planting. Periodical counts *i.e*., at 45 and 90 days after planting were made from the same area. The number of monocots (grasses + sedges) and dicots falling within the quadrate were counted and recorded. For dry weight, weed samples were collected twice, first at 90 DAP from 1.0 square meter area and expressed as g/m^2 and second at the time of final earthing up from entire net plot area of each plot and expressed as kg/ha. These samples were sun-dried and then finally dried in the electrical oven at 65 0C for 24 hours. The dry weight of weeds was recorded when samples attained a constant weight and expressed in g/m^2 and weed control efficiency (WCE) and weed index (WI) were calculated by using standard formula. Observations on growth characters *viz*., germination percentage (30 and 45 DAP), plant height (120, 180, 270 DAP and at harvest), tiller population (90, 135 and 180 DAP) and total dry matter accumulation was recorded as per the treatment. Moreover, yield character *viz*., millable cane length (cm), girth of cane (cm), number of internodes, single cane weight (g), number of millable canes, cane yield (t/ha) and sugarcane equivalent yield (t/ha) were recorded at the time of harvest. Whole cane samples were taken at the time of harvest and analyzed for quality parameters through standard laboratory procedures. The economics of experiment was worked out on the basis of the cost of cultivation and cane yield at prevailing market prices of the treatments. The uptake of N, P and K by sugarcane plant was calculated by multiplying the concentration with their respective dry matter yield (kg/ha). The percent available sugar was calculated as; available sugar (%) = {S – (B – S) x 0.4 x 0.73}, where S and B are sucrose and brix percent in cane juice, respectively. The trend of results was similar during both the years hence, data were subjected to pooled analysis for results and discussion.

Results and Discussion

(A) Growth parameters

(i) Effect of fertilizer levels: Data presented in [Table-1] denoted that germination was not influenced significantly by various treatments of fertilizer levels and weed management at 35 and 45 DAP. In case of plant height, 125 % RDF (F_3) recorded significantly higher plant height at 90 (67.7 cm), 180 (138.3 cm), 270 (228.1 cm) DAP and at harvest (334.4 cm) and it was found statistically at par with the 100 % RDF (F_2) during pooled analysis. While, treatment 75 % RDF (F_1) was inferior to the other fertilizer levels at all periodical stages of crop. However, significantly higher number of tillers per meter row length at 90, 135 and 180 DAP and total plant dry matter accumulation at harvest were recorded under the treatment 125 % RDF (F_3) and it being at par with the 100 % RDF (F_2) during pooled studies. This was obviously due to ample supplying of nutrient resulted in a greater number of sugarcane setts per meter row length. Such higher shoot height and dry matter accumulation might be due to the assured supply of nutrients during the grand growth stage, improved nutrient availability in the root zone to support the cell elongation and their proper development, which resulted in vigorous growth. The results confirm the findings of [2].

(ii) Effect of weed management: Plant height (74.2 & 153.8 cm) was found higher under treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) which was statistically at par with treatment W_4 at 90 DAP and it remained statistically at par with treatment W_6 at 180 DAP. However, at 270 DAP and at harvest, significantly higher plant height (248.4 and 353.5 cm) was recorded under the treatment W_2 and it remained statistically at par with treatment W_6 and W_5 during pooled analysis. While, treatment weedy check (W_1) recorded significantly the lowest plant height at all periodical observation during the course of investigation. At 90 DAP, significantly higher number of tillers per meter row length (15.9) was recorded under W_6 (Pendimethalin 1.0 kg/ha as pre-emergence + Sunnhemp as green manure crop harvested and mulched it at 50-60 DAP and incorporated at final earthing up) and it was found at par with treatment W_2. However at 135 and 180 DAP, significantly the higher number of tiller per row meter length (22.3 and 24.3) was recorded under the treatment W_2 (Three hand weedings at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) and it was found at par with the treatment W_6 (Pendimethalin 1.0 kg/ha as pre-emergence + sunnhemp as green manuring crop harvested and mulched it at 60 DAS and incorporated at final earthing-up), respectively. This happened due to less weed population and dry weight of weeds under the treatment W_2 & W_6 and also by virtue of reduced competition for nutrient, moisture and sunlight by weeds and harvesting of gram (W_5) and mulching of sunnhemp. Moreover, total dry matter accumulation (53.1 t/ha) was found higher under the treatment W_2 (Three hand weeding at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) and it was found statistically at par with treatment W_6 and W_5 during pooled analysis. While treatment W_1 (Weedy check) recorded lower dry matter accumulation at all periodical stages during both the years of experimentation and in the pooled analysis.

(B) Yield parameter

(i) Effect of fertilizer levels: Data indicating in [Table-2] revealed that the higher millable cane length (207.1 cm), number of internodes (22.1) and single cane weight (908.4 g) were observed under treatment 125 % RDF (F3) and it remained at par with 100 % RDF (F2) during pooled analysis. Significantly lower millable cane length (182.0 cm), number of internodes (18.6) and single cane weight (854.5 g) observed with 75 % RDF (F_1) during pooled analysis. However, fertilizer levels did not exert their significant effect on cane girth during experimentation. In case of numbers of millable cane per hectare, application of 125 % RDF (F3) was recorded a significantly higher number of millable canes per hectare (109,889) which was followed by treatment F2 (100% RDF) during pooled analysis and significantly the lowest numbers of millable canes per hectare (84173) were observed under the 75% RDF (F_1) at harvest during both the years of experimentation. The enhanced fertility status and more tillering which converting into higher number of millable canes also contributed to more cane yield. These findings are in close conformity with those of [3-5].

The higher cane yield (109.4 t/ha) and sugarcane equivalent yield (112.1 t/ha) were recorded under the treatment 125 % RDF (F_3) followed by treatment 100 % RDF (F_2) during pooled analysis, respectively. While, treatment F_1 (75 % RDF) was recorded significantly the lower cane yield (84.5 t/ha) and sugarcane equivalent yield (86.6 t/ha), respectively than the rest of all the treatments during pooled analysis. The increased cane yield in fertilizer levels (F_2) and (F_3) could be due to positive and significant correlation with number of millable cane per hectare, plant height, millable cane length, single cane weight and number of internodes per cane during both the years. However, higher dose of N promoting growth parameters might be due to fact that the net assimilation rate of the N fed to plants was accelerated due to increase in chlorophyll content and the absorbed N helped in the formation of food reservoir due to higher photosynthetic activity, which increases the growth character. Further, P also influences the cellular activity in the roots and leaves which resulted in increased yield. Similarly, the increased in growth and yield attributes may be due to the uncourageous effect of potassium on root development, formation of carbohydrates, regulation of water and translocation of photosynthates. These findings are in accordance with findings of [5-7].

Table-1 *Effect of fertilizer levels and weed management on growth attributes of sugarcane*

Treatments	Germination count (%)		Plant height (cm)				Number of tiller per row meter length			Dry matter accumulation (t/ha)
	35 DAP	45 DAP	90 DAP	180 DAP	270 DAP	At harvest	90 DAP	135 DAP	180 DAP	
Fertilizer levels (F)										
F_1	57.3	70.4	60.3	123.7	196.9	279.9	11.6	13.9	16.4	37.3
F_2	56.0	69.3	64.4	133.6	222.6	324.2	12.9	18.2	20.5	45.5
F_3	58.3	71.3	67.7	138.3	228.1	334.4	13.6	19.5	22.3	49.2
SEm ±	0.76	1.17	1.23	2.15	4.41	7.8	0.27	0.34	0.51	1.52
CD (P=0.05)	NS	NS	3.47	6.07	12.5	21.9	0.77	0.95	1.43	4.30
Weed management (W)										
W_1	55.7	69.4	54.7	99.5	158.3	265.4	8.5	12.8	14.5	32.9
W_2	56.5	71.3	74.2	153.8	248.4	353.5	15.9	22.3	24.3	53.1
W_3	57.9	71.5	64.9	121.4	203.6	285.9	10.8	15.1	17.5	40.4
W_4	57.9	71.5	69.5	131.9	214.6	303.8	11.6	14.5	17.6	41.3
W_5	57.7	68.1	59.5	138.5	232.9	330.8	13.5	17.5	18.7	47.5
W_6	57.9	70.3	62.0	146.1	237.5	337.8	16.0	21.1	23.3	48.8
SEm ±	1.07	1.66	1.74	3.04	6.24	11.0	0.38	0.47	0.72	2.15
CD (P=0.05)	NS	NS	4.90	8.58	17.6	30.9	1.08	1.34	2.03	6.07
Interaction (W x F)										
SEm ±	1.95	1.95	3.91	5.27	10.8	19.0	0.67	0.82	1.24	3.73
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	7.92	9.99	11.5	9.80	12.3	14.9	12.8	11.7	15.6	20.7

Table-2 *Effect of fertilizer levels and weed management on yield component and yield of sugarcane*

Treatments	Millable cane length (cm)	Number of internode	Girth of cane (cm)	Single cane weight (g)	Number of millable canes (ha)	Cane yield (t/ha)	Cane equivalent yield (t/ha)
Fertilizer levels (F)							
F_1	182.0	18.6	8.08	854.5	84173	84.5	86.6
F_2	199.2	21.4	8.13	898.4	101372	105.1	107.4
F_3	207.1	22.1	8.45	908.4	109889	109.4	112.1
SEm ±	3.14	0.45	0.12	11.2	1551	1.47	1.47
CD P=0.05)	8.86	1.28	NS	31.7	4382	4.16	4.15
Weed management (W)							
W_1	171.4	16.1	7.80	814.7	77263	78.4	78.4
W_2	218.7	25.4	8.52	931.9	124101	113.7	113.7
W_3	187.1	18.8	8.17	868.8	81643	94.1	94.1
W_4	185.0	19.0	8.14	875.6	85346	95.3	95.3
W_5	206.2	21.2	8.34	911.7	106894	107.2	121.4
W_6	208.3	23.7	8.35	919.9	115621	109.2	109.2
SEm ±	4.44	0.64	0.17	15.9	2194	2.08	2.08
CD (P=0.05)	12.5	1.81	NS	44.8	6191	5.88	5.87
Interaction (W x F)							
SEm ±	7.69	1.11	0.14	27.5	3800	3.61	3.60
CD(P=0.05)	NS	NS	NS	NS	NS	10.2	10.2
CV %	9.60	13.1	8.81	7.59	9.45	8.88	8.65

(ii) Effect of weed management: Different weed management module exerted their significant effect on yield component [Table-2] at harvest during experimentation. Significantly higher millable cane length (218.7 cm), number of internodes (25.4) and single cane weight (931.9 g) were noted under the treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) and it was remained at par with W_6. Treatment W_5 also remained at par with respect to single cane weight during pooled data analysis. While, significantly lower millable cane length (171.4 cm), number of internodes (16.1) and single cane weight (814.7 g) were observed under W_1 (Weedy check) during course of investigation. Furthermore, weed management did not exert its significant effect on cane girth during studies. Subject to numbers of millable cane per hectare, treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) was recorded a significantly higher number of millable canes per hectare (124101) followed by treatment W_6 (Pendimethalin 1.0 kg/ha as pre-emergence + sunnhemp as green manuring crop harvested and mulched it at 60 DAS and incorporated at final earthing-up). While, Weedy check (W_1) recorded significantly lower number of millable canes per hectare (77263) compared to rest of the treatments. The superiority of these all yield attributing characters under treatment W_2, may be due to less weed competition for space, light, moisture and nutrients. However, treatment W_5 and W_6 had suppressing effect of gram and sunnhemp leads to more competition for nutrient, space, light and water for weed population and dry weight of weeds therefore were found higher in treatment W_1 resulted into lower yield attributing characters than treatment W_2. While, compared to W_1 (Weedy check), treatment W_2 and W_6 had better yield attributing characters. This might be due to weeds have higher competitive ability for light, nutrient, space and water than gram and sunnhemp. These findings are in accordance with the findings of [8]. Weed management practices have marked effect on cane yield [Table-2] during experimentation. Treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) was recorded significantly the highest cane yield of 113.7 t/ha and it was remained at par with treatment W_6 during pooled analysis. While, the lowest cane yield of 78.4 t/ha were noted under weedy check (W_1).

This might be due to W_2, W_6 and W_5 treatments-controlled weeds effectively, reduced the competition by weeds to a greater extent and thus helped in faster growth and development of sugarcane crop, resulting in higher value of all yield attributing characters. It is also clear from the significant positive correlation between cane yield and sugarcane plant height, millable cane length and number of millable cane per meter row length. These results were supported by [9]. Undoubtedly, higher sugarcane equivalent yield (121.4 t/ha) was observed under treatment W_5 (Pendimethalin 1.0 kg/ha as pre-emergence + Gram as an intercrop) followed by treatment W_2 (113.7 t/ha) during pooled studies. While, significantly the lower sugarcane equivalent yield (78.4 t/ha) were recorded under W_1 (Weedy check) during both the years of investigation. It clearly indicated that intercrop gram very well compensated the reduction in the sugarcane yield. These results are in accordance with the finding of [14]. .

(iii) Interaction effect: During pooled analysis, significantly higher cane yield (125.0 t/ha) was recorded under the treatment combination F_3W_2 which were statistically at par with F_2W_2, F_3W_6, F_2W_6 and F_3W_5. While the lower cane yield was observed under the treatment combination F_1W_1, F_2W_1 and F_1W_3 during the course of the investigation. In case of sugarcane equivalent yield, higher sugarcane equivalent yield (135.1 t/ha) was found under the treatment combination F3W5 which were at par with F_2W_5 and F_3W_2. While the lowest cane yield was observed under the treatment combination F_1W_1, F_2W_1 and F_1W_3 during pooled analysis [Table-3].

Table-3 *Interaction effect of fertilizer levels and weed management on cane yield and sugarcane equivalent yield*

Treatments	Cane yield (t/ha)			Sugarcane equivalent yield (t/ha)		
Weed management (W)	Fertilizer levels (F)			Fertilizer levels (F)		
	F_1	F_2	F_3	F_1	F_2	F_3
W_1	71.8	76.8	86.6	71.8	76.8	86.6
W_2	92.5	123.7	125.0	92.5	123.7	125.0
W_3	80.6	99.1	102.5	80.6	99.1	102.5
W_4	85.8	98.7	101.5	85.8	98.7	101.5
W_5	90.7	112.3	118.6	103.2	126.0	135.1
W_6	85.6	120.1	122.0	85.6	120.1	122.0
SEm ±	3.61			3.60		
CD (P=0.05)	10.2			10.2		
CV %	8.88			8.65		

(C) Weed parameter

Weed flora: Predominant weed species of sugarcane at experimental site which was consisting of narrow leaved weeds were *Cynodon dactylon* L., *Sorghum halepense* L., *Dactyloctenium aegyptium* L., *Brachiaria ramosa* L., *Echinochloa crusgalli* L., *Echinochloa colonum* L. and broad leaved weeds were *Portulaca oleracea* L., *Phyllanthus moderaspatenia* L., *Alternanthera sessilis* L., *Eclipta alba* (L.) Hassk, *Euphorbia hirta* L., *Centella asiatica* Urb., *Digera arvensis* Forsk, *Melilotus indica* (L.) All., *Operculina turpenthum* L., *Physalis minima* L., *Hibiscus* spp., *Corchorus acutangulus* L., *Abutilos indicum* L. and *Medicago sativa* L. While *Cyperus rotundus* L. was the only predominant sedge weed observed in the experimental fields.

(i) Effect of fertilizer levels: The data pertaining to weed counts (monocots, dicots, sedges and total weeds) at 45 and 90 DAP are given in [Table-4 and 5]. It was observed that the effect of fertilizer levels on weed population at 45 and 90 DAP was found to be non-significant during study and also dry weight of weed did not differ significantly due to different fertilizer levels at 90 DAP and at final earthing up.

(ii) Effect of weed management: At 45 DAP, significantly lower number of monocots weeds (8.7 and 13.3 m^{-2}) at were recorded under the treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) during the individual year as well as in pooled studies and it was found statistically at with W_3 and W_4 during second year only. However, maximum number of monocot weeds (22.7 and 27.3 m^{-2}) were recorded under the treatment W_1 (Weedy check) during all the individual year. However, treatment W_2 and W_4 recorded significantly lower number of dicot weeds (5.11 and 3.78 m^{-2}) during first and second year and found statistically at par with each other, treatment weedy check (W_1) recorded significantly higher number of dicot weeds (13.6 and 11.2 m^{-2}) during all the individual year. Significantly lower number of sedges (19.7 and 31.6 m^{-2}) were recorded under the treatment W_2 during both the years of experimentation, which was found statistically at with the treatment W_3 and W_4 during first year; W_4 and W_6 during second year. While, treatment weedy check (W_1) recorded significantly higher number of sedges weeds (45.7 and 57.7 m^{-2}) during all the individual year. Total weeds count (33.4, 48.8 and 41.1 m^{-2}) was recorded significantly lower under treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) during both the year as well as in pooled analysis. However, treatment W_1 (Weedy check) recorded significantly higher number of total weeds (82.1, 96.3 and 89.2 m^{-2}) during both years as well as in the pooled analysis, respectively.

At 90 DAP, significantly lower number of monocot weeds (8.9 and 6.3 m^{-2}) were found under the treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) during both the year of experimentation, respectively. It was found statistically at par with treatment W_5 and W_6 during first year. However, W_1 (Weedy check) recorded significantly higher number of monocot weeds (28.6 and 28.9 m^{-2}) under during both the year. Similarly, dicot weeds (7.0 and 7.11 m^{-2}) and sedges (27.0 and 37.0 m^{-2}) were found significantly lower under the treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) during both the years of experimentation. Which was found statistically at par with the treatment W_5 and W_6 during both the years. However, maximum number of dicot weeds (15.6 and 14.5 m^{-2}) and sedges (55.7 and 62.4 m^{-2}) observed under the treatment W_1 (Weedy check) during both the year. Total number of weeds (43.6, 50.4 and 47.0 m^{-2}) were also recorded lower under the treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) which was followed by treatment W_5 and W_6 during both the years as well as in pooled analysis. However, W_1 (Weedy check) recorded significantly highest number of total weeds (99.9, 106.3 and 103.1 m^{-2}).

In general, the weeds population was recorded in the chronological manner of $W_2<W_5<W_6<W_4<W_3<W_1$. These results are in accordance with the findings of [13] who observed minimum weed population with conventional hand weeding practices over weedy check. Treatment W_5 and W_6 were also found significantly superior with respect weed population (dicots, monocots and total weeds) at 45 and 90 DAP over W_1 during both the years except dicot weeds at 90 DAP in W_4 during second year. This might be due to application of Pendimethalin as pre-emergence and also profuse growth of intercrops (gram and sunnhemp) suppressed the weed population and their growth. These results are in conformity with those of [11] who reported that application of pre-emergence weedicide effectively controlled the weeds; Patel, (2000) also observed marked reduction in dicot weeds at 45 and 90 DAP when intercropped with gram; [12] also reported that intercropping of sunnhemp suppressed the weed growth. These result also in conformity with [10]. Dry weight of weeds (22.9 and 283.4 g/m^2) at 90 DAP and at final earthing up was recorded significantly lower under the treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) during pooled analysis which was found statistically at par with treatment W_5 only at 90 DAP. However, all the weed management treatments were found in the order of $W_2<W_6<W_5<W_4<W_3<W_1$ during pooled analysis [Table-6]. Results clearly indicated that the highest weed control efficiency (69.2 %) were recorded with treatment W_2 (Three HW at 30, 60 & 90 DAP + Two IC at 45 & 90 DAP) followed by W_6 and W_5 during pooled analysis. The data presented in [Table-6] showed the influence of various weed management treatments on weed competition index. Treatment W_6 (Pendimethalin 1.0 kg/ha as pre-emergence + Sunnhemp as a green manure crop harvested and mulched it at 50-60 DAP and incorporated at final earthing up) and W_5 (Pendimethalin 1.0 kg/ha as pre-emergence + Gram as a intercrop) recorded the lower weed competition index (3.95 and 5.74 %) found most effective in controlling the weeds, after the treatment W_2 during both the years and in pooled analysis, respectively [Table-6]. These results were as per expectation as conventional method and Pendimethalin 1.0 kg/ha as pre-emergence + intercrops (gram or sunnhemp) check weed growth up to 90 DAP and late emerged weeds flush may be smothered by intercrop and vigorous sugarcane crop growth. These results are supported by [13].

(D) Economic analysis

(i) Effect of fertilizer levels: The data on the economics of sugarcane crop as influenced by fertilizer levels and weed management are furnished in [Table-7]. Data revealed that the treatment receiving a higher level of fertilizer (F_3: 125 % RDF) registered maximum gross realization (₹ 392423/ha) and net realization (₹ 277802/ha) with B:C ratio of 2.42 followed by treatment F_2 with gross realization of ₹ 37594/ha, net realization of ₹ 264105/ha and B:C ratio of 2.36. While, the lowest gross (₹ 303007/ha) and net realization (₹ 194271/ha) respectively with B: C ratio of 1.79 was obtained under F_1 (75 % RDF) treatment.

(ii) Effect of weed management: The highest gross realization (₹ 425013/ha), net-realization (₹ 309579/ha) and B:C ratio (2.68) was obtained with the treatment W_5 (Pendimethalin 1.0 kg/ha as pre-emergence + gram as an intercrop) followed by treatment W_2 and W_6. While, the lowest gross realization (₹ 274363/ha), net realization (₹ 174416/ha) and B:C ratio (1.75) was obtained under W_1 (Weedy check) treatment.

Table-4 *Effect of fertilizer levels and weed management on weed density at 45 DAP*

Treatments	Weed density /m² at 45 DAP															
	Monocot				Dicot				Sedges				Total			
	2016-17		2017-18		2016-17		2017-18		2016-17		2017-18		2016-17		2017-18		Pooled	
Fertilizer levels (F)																		
F_1	3.86	(15.1)	4.40	(19.4)	2.74	(7.22)	2.53	(6.39)	5.36	(29.0)	6.38	(40.6)	7.09	(51.3)	8.11	(66.5)	7.60	(58.9)
F_2	4.14	(17.2)	4.49	(20.2)	3.19	(10.3)	2.74	(7.44)	5.81	(35.1)	6.72	(46.1)	7.76	(62.7)	8.50	(73.8)	8.13	(68.2)
F_3	3.87	(14.7)	4.23	(17.7)	2.97	(8.67)	2.66	(6.94)	5.51	(30.4)	6.30	(39.6)	7.30	(53.8)	8.01	(64.3)	7.65	(59.1)
SEm ±	0.12		0.11		0.13		0.08		0.20		0.43		0.27		0.22		0.17	
CD (P=0.05)	NS		NS		NS		NS		NS		NS		NS		NS		NS	
Weed management (W)																		
W_1	4.77	(22.7)	5.25	(27.3)	3.70	(13.6)	3.40	(11.2)	6.65	(45.7)	7.53	(57.7)	8.95	(82.1)	9.74	(96.3)	9.35	(89.2)
W_2	2.99	(8.7)	3.70	(13.3)	2.36	(5.11)	2.06	(3.78)	4.47	(19.7)	5.67	(31.6)	5.80	(33.4)	7.01	(48.8)	6.40	(41.1)
W_3	3.81	(14.1)	3.94	(15.1)	2.95	(8.33)	2.34	(5.22)	5.04	(25.0)	6.56	(42.6)	6.91	(47.4)	7.96	(63.0)	7.43	(55.2)
W_4	3.93	(15.1)	4.05	(16.1)	2.66	(6.78)	2.04	(3.89)	5.17	(26.5)	6.23	(38.5)	6.95	(48.4)	7.65	(58.6)	7.30	(53.5)
W_5	4.18	(17.1)	4.71	(21.8)	3.13	(9.56)	2.91	(8.00)	6.19	(37.8)	6.70	(44.5)	8.04	(64.6)	8.64	(74.3)	8.34	(69.4)
W_6	4.06	(16.4)	4.61	(21.1)	2.99	(9.00)	3.14	(9.44)	5.82	(34.2)	6.11	(37.7)	7.65	(59.7)	8.22	(68.2)	7.93	(63.9)
SEm ±	0.18		0.16		0.18		0.12		0.29		0.25		0.38		0.31		0.24	
CD (P=0.05)	0.50		0.46		0.52		0.34		0.82		0.73		1.08		0.88		0.69	
Interaction (W x F)																		
SEm ±	0.30		0.28		0.31		1.05		0.50		0.44		0.65		0.53		0.42	
CD (P=0.05)	NS		NS		NS		NS		NS		NS		NS		NS		NS	
CV %	13.3		10.9		18.5		13.6		15.6		11.8		15.3		11.2		13.2	

Note: Figure in parenthesis refers to original value and outside the parenthesis indicates (√X+0.5) transformed value

Table-5 *Effect of fertilizer levels and weed management on weed density at 90 DAP*

Treatments	Weed density /m² at 90 DAP															
	Monocot				Dicot				Sedges				Total			
	2016-17		2017-18		2016-17		2017-18		2016-17		2017-18		2016-17		2017-18		Pooled	
Fertilizer levels (F)																		
F_1	3.99	(16.4)	3.70	(14.5)	3.05	(9.0)	3.48	(12.1)	6.02	(36.4)	6.70	(45.0)	7.80	(61.8)	8.39	(71.6)	8.10	(66.7)
F_2	4.15	(17.6)	3.89	(15.8)	3.44	(11.7)	3.20	(10.2)	6.51	(43.4)	6.97	(49.3)	8.41	(72.8)	8.60	(75.3)	8.50	(74.1)
F_3	3.62	(13.7)	3.94	(16.2)	3.30	(10.8)	3.56	(12.4)	6.30	(39.6)	6.78	(45.9)	7.96	(64.2)	8.61	(74.6)	8.28	(69.4)
SEm ±	0.15		0.11		0.12		0.12		0.18		0.17		0.23		0.16		0.14	
CD (P=0.05)	NS		NS		NS		NS		NS		NS		NS		NS		NS	
Weed management (W)																		
W_1	5.30	(28.6)	5.39	(28.9)	3.97	(15.6)	3.88	(15.0)	7.39	(55.7)	7.84	(62.4)	9.89	(99.9)	10.29	(106)	10.0	(103)
W_2	3.04	(8.9)	2.59	(6.3)	2.72	(7.00)	2.75	(7.11)	5.29	(27.7)	6.11	(37.0)	6.63	(43.6)	7.13	(50.4)	6.88	(47.0)
W_3	4.32	(18.3)	4.61	(21.0)	3.41	(11.3)	3.75	(14.0)	6.80	(45.9)	7.00	(48.6)	8.71	(75.6)	9.15	(83.6)	8.93	(79.6)
W_4	4.11	(16.8)	4.31	(18.3)	3.37	(11.0)	3.60	(13.0)	6.49	(42.2)	7.12	(50.3)	8.36	(70.0)	9.05	(81.7)	8.70	(75.8)
W_5	3.56	(12.3)	3.08	(9.3)	3.10	(9.44)	3.06	(9.00)	5.78	(33.0)	6.41	(40.8)	7.42	(54.8)	7.71	(59.1)	7.57	(56.9)
W_6	3.20	(10.6)	3.07	(9.1)	2.99	(8.67)	3.44	(11.3)	5.90	(34.6)	6.42	(41.3)	7.34	(53.8)	7.86	(61.8)	7.60	(57.8)
SEm ±	0.21		0.16		0.16		0.17		0.25		0.24		0.32		0.23		0.20	
CD (P=0.05)	0.61		0.47		0.48		0.48		074		0.70		0.92		0.65		0.55	
Interaction (W x F)																		
SEm ±	0.37		0.28		0.29		0.29		0.44		0.42		0.55		0.39		0.34	
CD (P=0.05)	NS		NS		NS		NS		NS		NS		NS		NS		NS	
CV %	16.3		12.7		15.5		15.5		12.4		10.7		11.9		7.95		10.0	

Note: Figure in parentheses refers to original value and outside the parentheses indicates (√X+0.5) transformed value

Table-6 Effect of fertilizer levels and weed management on dry weights of weeds, weed control efficiency and weed index

Treatments	Dry weight at 90 DAP (g/m²)	Dry weight at final earthing up (kg/ha)	Weed control efficiency (%)	Weed index (%)
Fertilizer levels (F)				
F_1	33.7	524.1	-	-
F_2	33.7	497.8	-	-
F_3	35.8	493.9	-	-
SEm ±	0.93	14.2	-	-
CD (P=0.05)	NS	NS	-	-
Weed management (W)				
W_1	58.0	943.1	0	31.0
W_2	22.9	283.4	69.2	0
W_3	36.6	521.1	42.4	17.2
W_4	35.0	495.6	45.9	16.1
W_5	26.4	403.3	56.1	5.74
W_6	27.6	384.9	58.3	3.95
SEm ±	1.32	20.1	-	-
CD (P=0.05)	3.71	56.8	-	-
Interaction (W x F)				
SEm ±	2.28	34.9	-	-
CD (P=0.05)	NS	NS	-	-
CV %	16.2	16.9	-	-

Table-7 Effect of fertilizer levels and weed management on economic analysis of sugarcane (Pooled data of two cycles)

Treatments	Cane equivalent yield (t/ha)	Gross realization (₹/ha)	Cost of production (₹/ha)	Net realization (₹/ha)	B:C ratio
Weed management (W)					
F_1	86.6	303007	108736	194271	1.79
F_2	107.4	375794	111689	264105	2.36
F_3	112.1	392423	114621	277802	2.42
Fertilizer levels (F)					
W1	78.4	274363	99947	174416	1.75
W_2	113.7	398062	112961	285101	2.52
W_3	94.1	329238	107163	222075	2.07
W_4	95.3	333560	108313	225247	2.08
W_5	121.4	425013	115434	309579	2.68
W_6	109.2	382211	109796	272415	2.48

Conclusion

From the economics point of view, it can be concluded that the application of 100% RDF (250: 125: 125, N:P_2O_5 :K_2O kg/ha) along with pre-emergence application of Pendimethalin 1.0 kg/ha with gram as an intercrop were superior in controlling weeds, improving growth & productivity and realizing higher net returns and B :C ratio of sugarcane.

Application of research: Fertilizer and Weed management

Research Category: Agronomy

Abbreviations: DAS: Days after sowing, DAP: Days after planting, HW: Hand Weeding, IC: Interculturing, RDF: Recommended dose of fertilizer, HA: Hectare, C.C.S: Commercial cane sugar

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Study area / Sample Collection: Research farm of Navsari agricultural University, Navsari

Cultivar / Variety / Breed name: Sugarcane (*Saccharum officinarum* L.)

Conflict of Interest: None declared

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