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Effect of plant growth regulator Cycocel on growth, yield and economics of *Rabi* Sorghum (*Sorghum bicolor* L.) under rainfed conditions

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Abstract
A field experiment was conducted at Agricultural Research Station, Tandur, Professor Jayashankar Telangana State Agricultural University during 2018-19 & 2019-20 to study the response of Cycocel in terms of growth characters, yield attributes and economics. In the present study, ten treatments were included i.e. 1. Cycocel spray @ 500 ppm at knee height stage (45 DAS), 2. Cycocel spray @ 500 ppm at booting stage (65 DAS), 3. Cycocel spray @ 1000 ppm at knee height stage (45 DAS), 4. Cycocel spray @ 1000 ppm at booting stage (65 DAS), 5. Cycocel spray @ 500 ppm both at knee height stage (45 DAS) and at booting stage (65 DAS), 6. Cycocel spray @ 1000 ppm both at knee height stage (45 DAS) and at booting stage (65 DAS), 7. Simple water spray at knee height stage (45 DAS), 8. Simple water spray at booting stage (65 DAS), 9. Simple water spray both at knee height stage (45 DAS) and at booting stage (65 DAS) and 10. Control. The treatments were evaluated in Randomized Block Design (RBD) with three replications. The pooled results of the study revealed that Cycocel (CCC) spray @ 1000 ppm at knee height stage (45 DAS) and booting stage (65 DAS) record significantly lowest plant height (181.1 cm) and highest grain yields (2309 kg ha^{-1}) of Rabi Sorghum. The gross monetary returns (Rs. 73868 ha^{-1}), net returns (Rs. 48868 ha^{-1}) and B:C ratio (1.94) were also significantly highest with Cycocel spray @ 1000 ppm at knee height stage (45 DAS) and booting stage (65 DAS).

Keywords: Cycocel, *Rabi* sorghum, yield and economics

Introduction
Rabi sorghum is valued mainly as staple food of humans in rainfed ecosystem and fodder for livestock. It is predominately grown in Maharashtra followed by Karnataka, Tamil Nadu, Andhra Pradesh, Gujarat and Telangana. In India, *Rabi* Sorghum is cultivated in an area of 29.64 lakh ha with a production of 25.29 lakh tons and productivity of 853 kg ha^{-1}. In Telangana, this crop occupies an area of 0.24 lakh ha with a production 0.32 lakh tons and an average yield of 1351 kg ha^{-1} (INDIASTAT, 2017-18) [4].

The modern *Rabi* Sorghum genotypes are typically characterized by the plants with thin culm girth and heavier panicle size, which make them more and more susceptible to lodging at maturity. Hence, enhancing the source to sink ratio by inhibiting the vegetative growth of *Rabi* Sorghum through plant growth inhibitors, besides increasing the grain yields, also imparts resistance to lodging.

Lodging at the maturity is one of the problem in native cultivars cultivation. The application of plant growth retardant is controlling the lodging of grain cereals like wheat, rice, rye and barley. At present among growth retardant, Cycocel has the greatest consumption rate. Cycocel (CCC) is between most wide spread growth retardant of plants and recently is utilized greatly to decrease the lodging and to control the crop growth (Emam, 2003) [2]. Lodging is decreased by using of Cycocel, which facilitates harvesting and yield loss will be reduced (Mohsen zade *et al.*, 2003) [5]. Cycocel treatment decreases the cell size and increases the cell wall thickness, thickness all the sap, increases the number of stem sets, decreases the length of internodes and increases the stem diameter. Using the Cycocel decreases the plant height up to 23% and significantly increases the grain yield (Singh *et al.*, 2002) [10]. Keeping in view the above facts, the present experiment was conducted to study the effect of Cycocel on growth and yield of *Rabi* Sorghum.

Materials and Methods

A field experiment was conducted at Agriculture Research Station, Tandur, Professor Jayashankar Telangana State Agricultural University form 2018-19 to 2019-20. The soil of the experimental field was clayey in texture, low in organic carbon (0.24 %), low in available nitrogen (151 kg ha^{-1}), high in available phosphorus (32 kg ha^{-1}), high in available potassium (414 kg ha^{-1}) and slightly alkaline in reaction (pH 7.39). The following treatments were included in the present study *viz* 1. Cycocel spray @ 500 ppm at knee height stage (45 DAS), 2. Cycocel spray @ 500 ppm at booting stage (65 DAS), 3. Cycocel spray @ 1000 ppm at knee height stage (45 DAS), 4. Cycocel spray @ 1000 ppm at booting stage (65 DAS), 5. Cycocel spray @ 500 ppm both at knee height stage (45 DAS) and at booting stage (65 DAS), 6. Cycocel spray @ 1000 ppm both at knee height stage (45 DAS) and at booting stage (65 DAS), 7. Simple water spray at knee height stage (45 DAS), 8. Simple water spray at booting stage (65 DAS), 9. Simple water spray both at knee height stage (45 DAS) and at booting stage (65 DAS) and 10. Control. The treatments were evaluated in Randomized Block Design (RBD) with three replications. Sorghum cv. CSV-29 R was sown with spacing of 45 cm x 10 cm in the third week of October and harvested in second week of February during two years. RDF (60:30 NP Kg ha^{-1}) was applied to soil in each treatment at the time of sowing. Net plot yield was converted into hectare basis. The results were analyzed using standard statistical procedure given by Panse and Sukhatme (1967) [7].

Result and Discussion

Growth and Yield Parameters

The pooled analysis of results revealed that, none of the treatments exhibited significant difference except plant height (Table.1). The lowest plant height (181.1cm) was recorded with Cycocel spray @ 1000 ppm both at knee height stage (45 DAS) and booting stage (65 DAS) followed by Cycocel spray @ 500 ppm both at knee height stage (45 DAS) and booting stage (65 DAS). According to Shekoofa and Emam (2008) [9], Cycocel spray resulted in reduction of plant height and it was associated with reduced elongation of the internodes, rather than lowering the number of internodes. Bahrami *et al.* (2014a) [1] noticed that Cycocel foliar spray in barley plants had lower plant height at the early stages. According to Pirasteh Anosheh1 (2016) [3] Cycocel is used for reduction in plant height to prevent stem lodging.

Cycocel (CCC) spray @ 1000 ppm both at knee height stage (45 DAS) & booting stage (65 DAS) recorded significantly highest panicle width (12.3 cm) of *Rabi* Sorghum when compared to other treatments (Table. 2).

Table 1: Effect of Cycocel (CCC) on growth parameters of *Rabi* Sorghum

Sl. No	Treatments	Plant height (cm)			50% flowering			Biomass (t ha^{-1})		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
1	CCC spray @ 500 ppm at knee height stage (45 DAS)	196.9	184.0	190.4	71	69	70	7.75	5.12	6.43
2	CCC spray @ 500 ppm at booting stage (65 DAS)	206.5	186.3	196.4	71	71	71	7.77	5.06	6.42
3	CCC spray @ 1000 ppm at knee height stage (45 DAS)	190.7	182.3	186.5	70	70	70	7.95	5.37	6.66
4	CCC spray @ 1000 ppm at booting stage (65 DAS)	202.8	186.9	194.8	70	70	70	7.94	5.20	6.57
5	CCC spray @ 500 ppm at knee height stage (45 DAS) + 500 ppm at booting stage (65 DAS)	189.4	181.0	185.2	71	70	71	7.98	5.15	6.56
6	CCC spray @ 1000 ppm at knee height stage (45 DAS) + 1000 ppm at booting stage (65 DAS)	185.3	176.9	181.1	70	70	70	8.15	5.70	6.92
7	Simple water spray at knee height stage (45 DAS)	223.6	204.1	213.9	71	69	70	7.84	5.45	6.65
8	Simple water spray at booting stage (65 DAS)	225.9	206.3	216.1	70	70	70	7.97	5.45	6.71
9	Simple water spray at knee height stage (45 DAS) and at booting stage (65 DAS)	224.2	206.7	215.4	70	70	70	8.54	6.03	7.29
10	Control	222.7	202.6	212.6	71	69	70	7.63	5.31	6.47
SEm±		5.88	9.79	7.31	0.62	0.41	0.37	0.32	0.39	0.31
CD @5%		17.61	NS	21.87	NS	NS	NS	NS	NS	NS
CV (%)		4.92	8.85	6.35	1.52	1.01	0.92	6.93	12.83	8.02

Table 2: Effect of Cycocel (CCC) on yield parameters of *Rabi* Sorghum

Sl. No	Treatments	Panicle length (cm)			Panicle width (cm)			Test wt. (gm)		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
1	CCC spray @ 500 ppm at knee height stage (45 DAS)	20.3	19.7	20.0	11.3	12.3	11.8	3.39	3.28	3.33
2	CCC spray @ 500 ppm at booting stage (65 DAS)	21.0	19.7	20.4	11.4	11.2	11.3	3.55	3.35	3.45
3	CCC spray @ 1000 ppm at knee height stage (45 DAS)	21.9	19.0	20.5	12.4	12.1	12.3	3.57	3.31	3.44
4	CCC spray @ 1000 ppm at booting stage (65 DAS)	21.5	19.9	20.7	12.1	12.5	12.3	3.46	3.41	3.43
5	CCC spray @ 500 ppm at knee height stage (45 DAS) + 500 ppm at booting stage (65 DAS)	21.5	19.5	20.5	12.1	12.0	12.0	3.52	3.44	3.48
6	CCC spray @ 1000 ppm at knee height stage (45 DAS) + 1000 ppm at booting stage (65 DAS)	21.9	19.9	20.9	12.3	12.3	12.3	3.33	3.47	3.40
7	Simple water spray at knee height stage (45 DAS)	21.3	19.6	20.5	11.5	12.3	11.9	3.45	3.31	3.38
8	Simple water spray at booting stage (65 DAS)	21.1	19.1	20.1	12.0	11.9	11.9	3.09	3.33	3.21
9	Simple water spray at knee height stage (45 DAS) and at booting stage (65 DAS)	21.5	20.1	20.8	12.1	12.2	12.1	3.44	3.33	3.38
10	Control	20.9	19.7	20.3	11.2	11.5	11.4	3.22	3.21	3.22
SEm±		0.43	0.59	0.35	0.36	0.34	0.20	0.14	0.12	0.12
CD @5%		NS	NS	NS	NS	NS	0.60	NS	NS	NS
CV (%)		3.46	5.21	2.95	5.33	4.91	2.89	7.35	6.37	5.93

Grain and Stover Yield

The highest grain yield (2309 kg ha^{-1}) was recorded with Cycocel spray @ 1000 ppm both at knee height stage (45 DAS) & booting stage (65 DAS) and it was on par with Cycocel spray @ 500 ppm both at knee height stage (45 DAS) & booting stage (65 DAS) (2082 kg ha^{-1}) and Cycocel spray @ 1000 ppm at booting stage (65 DAS) (2059 kg ha^{-1}). Straw yield and harvest index were not significantly affected by the treatments (Table. 3). Foliar spray of Cycocel at 4-leaf stage significantly increased grain yield of wheat (Moona latifkar, 2014) [6]. Cycocel spray produces more photosynthates and more assimilates are mobilized towards grains and lead to the increase of grain yield (Sharif *et al.*, 2007) [8]. Singh *et al.*, (1972) [11] have shown that application of Cycocel decreased the plants height 23% which resulted in a significant increase of grain yield.

Table 3: Effect of Cycocel (CCC) on yield of *Rabi* Sorghum

Sl. No	Treatments	Grain yield (kg ha^{-1})			Fodder yield (kg ha^{-1})			Harvest Index (%)		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
1	CCC spray @ 500 ppm at knee height stage (45 DAS)	2616	1098	1857	5130	4019	4574	33.75	22.0	27.9
2	CCC spray @ 500 ppm at booting stage (65 DAS)	2707	1110	1909	5065	3954	4509	35.14	22.5	28.8
3	CCC spray @ 1000 ppm at knee height stage (45 DAS)	2679	1209	1944	5269	4157	4713	33.72	23.3	28.5
4	CCC spray @ 1000 ppm at booting stage (65 DAS)	2873	1244	2059	5065	3954	4509	36.31	24.0	30.1
5	CCC spray @ 500 ppm at knee height stage (45 DAS) + 500 ppm at booting stage (65 DAS)	2852	1312	2082	5130	3833	4481	35.70	25.9	30.8
6	CCC spray @ 1000 ppm at knee height stage (45 DAS) + 1000 ppm at booting stage (65 DAS)	2978	1639	2309	5171	4060	4616	36.57	29.4	33.0
7	Simple water spray at knee height stage (45 DAS)	2196	913	1554	5648	4537	5093	27.92	18.8	23.3
8	Simple water spray at booting stage (65 DAS)	2381	980	1681	5584	4473	5029	29.84	19.2	24.5
9	Simple water spray at knee height stage (45 DAS) and at booting stage (65 DAS)	2640	1246	1943	5898	4787	5343	30.98	21.8	26.4
10	Control	2126	924	1525	5500	4389	4944	27.78	18.3	23.0
SEm±		155.68	147.31	121.31	290.26	422.84	318.61	1.88	3.20	2.19
CD @5%		466.15	NS	363.21	NS	NS	NS	5.63	NS	NS
CV (%)		10.35	22.57	11.14	5130	17.37	11.54	9.94	25.16	13.72

Table 4: Effect of Cycocel (CCC) on economics of *Rabi* Sorghum

Sl. No	Treatments	Gross returns (Rs ha^{-1})			Net returns (Rs ha^{-1})			BC ratio		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
1	CCC spray @ 500 ppm at knee height stage (45 DAS)	83352	41509	62431	58852	18009	38431	2.40	0.77	1.58
2	CCC spray @ 500 ppm at booting stage (65 DAS)	85403	41597	63500	60903	18097	39500	2.49	0.77	1.63
3	CCC spray @ 1000 ppm at knee height stage (45 DAS)	85425	44782	65104	60425	20782	40604	2.42	0.87	1.64
4	CCC spray @ 1000 ppm at booting stage (65 DAS)	89560	44940	67250	64560	20940	42750	2.58	0.87	1.73
5	CCC spray @ 500 ppm at knee height stage (45 DAS) + 500 ppm at booting stage (65 DAS)	89250	46213	67731	63750	21713	42731	2.50	0.89	1.69
6	CCC spray @ 1000 ppm at knee height stage (45 DAS) + 1000 ppm at booting stage (65 DAS)	92544	55192	73868	67044	30692	48868	2.63	1.25	1.94
7	Simple water spray at knee height stage (45 DAS)	74657	38694	56676	51157	16194	33676	2.18	0.72	1.45
8	Simple water spray at booting stage (65 DAS)	79082	40165	59624	55582	17665	36624	2.37	0.79	1.58
9	Simple water spray at knee height stage (45 DAS) and at booting stage (65 DAS)	86634	47894	67264	62634	24894	43764	2.61	1.08	1.85
10	Control	72407	38454	55431	49407	16454	32931	2.15	0.75	1.45

Economics

Maximum net returns of Rs. 48,868 ha^{-1} with BCR of 1.94 was recorded with Cycocel spray @ 1000 ppm both at knee height stage (45 DAS) & booting stage (65 DAS) (Table. 4).

The results of the research showed that Cycocel spray @ 1000 ppm at knee height stage (45 DAS) & booting stage (65 DAS) recorded higher grain yield, net returns and B: C ratio in *Rabi* Sorghum.

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