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Effect of growth substances on morpho-physiological traits and yield in pearl millet under rainfed condition

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Abstract
Field experiment was carried out to find out the effect of foliar spray of plant growth retardant substances on different growth parameter of pearl millet under rainfed condition during *kharif* 2015-17. The results revealed that foliar application of growth regulating substances had significant impact on number of effective tillers, plant height and chlorophyll content. Plant height and chlorophyll content at 70 days after sowing were significantly affected with application of growth regulating substances in all individual years as well as in pool analysis. Results indicated that foliar application of potassium chloride 1.50 per cent at 30-35 days after sowing (tillering stage) and 50-55 days after sowing (post-anthesis stage) for proper vegetative growth and to get higher seed yield and net return. The results also indicated that net return (Rs. 27245 /ha) was maximum with foliar application of potassium chloride 1.50% at tillering and post-anthesis stage along with B:C ratio 1.16.

Keywords: growth regulators, pearl millet, potassium chloride, benzyl adenine and chlorophyll content

Introduction
Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the staple nutritious food of the poor and small land holders, as well as feed and fodder for livestock in rainfed regions of the country. Pearl millet excels all the cereals due its unique features-C4 plant with high photosynthetic efficiency, high dry matter production capacity and is grown under the most adverse agro-climatic condition with less inputs in short duration where other crops like sorghum and maize fail to produce economic yields. The major pearl millet growing states are Rajasthan, Maharastra, Gujarat, Uttar pradesh and Haryana which account for more than 90% of pearl millet acreage in the country and commonly grown in rainfed season. It occupies an area of 6.93 million ha with an average production of 8.61 million tonnes and productivity of 1243 kg/ha (Directorate of Millets Development, 2020; Coordinator Review, 2020).
The plant growth regulators (PGRs) have potential for increasing crop productivity under environmental stress. Growth regulators are chemical substances which can alter the growth and developmental processes (Espindula *et al*., 2009) [5] leading to increased yield, improved grain quality or facilitated harvesting. Pearl millet responds well to plant growth regulators application and the increase due to each successive level of growth regulators applied was significant for earhead length, earhead girth and test weight. The positive effect of plant growth regulators application on yield attributing characters of pearl millet seems to be due to cumulative effect on growth and vigour of plants. Plant growth regulators are known to play a positive role in enhancing qualitative and quantitative characters in plants. Based on this background a study was initiated to analyze the effect of foliar application of growth regulators on physiological parameters, morphological, grain yield and quality. Foliar application of potassium improved the drought tolerance, growth and yield components in wheat (Aown *et al.* 2012) [3]. Chang *et al.* (2016) [4] reported that the exogenous application of cytokinin delayed leaf wilting under drought stress. Thiourea is effective in improving plant growth and development under drought, salinity, heat stress and heavy metal toxicity. At physiological level, it improves the leaf gas exchange, nutrient acquisition by the root and assimilation thereafter. At biochemical level, exogenously applied thiourea improves the sugar metabolism and enhances the proteins biosynthesis (Wahid *et al*., 2017) [3, 10]. With this basis, the present investigation was focused on physiological, biochemical and yield attributes in pearl millet by foliar application of nutrients and PGRs under drought condition.

Materials and Methods

A field experiment on pearl millet hybrid GHB 558 was conducted at Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar during rainy season 2014 to 2016. The experiment was laid out in randomized block design with four replications and seven treatments *viz*., Distilled water (T_2), Thiourea 1000 ppm (T_3), Benzyl adenine 25 ppm (T_4), Benzyl adenine 50 ppm (T_5), Potassium chloride 0.75% (T_6) and Potassium chloride 1.50% (T_7) were applied as foliar spray at tillering and post-anthesis stage. The gross plot size was 5.0 m x 2.4 m (four row of five meters length) and net plot size was 4.0 m x 1.2 m (two row of four meters length). All the recommended agronomical practices and plant protection measures were followed for raising a good crop. The observations *viz.*, grain yield, fodder yield, dry ear head weight and total dry matter yield were noted on net plot basis and converted in to kg/ha. The field observations *viz*., days to 50 per cent flowering, days to maturity and 1000 grain weight were recorded on plot basis while, number of effective tillers, plant height and total chlorophyll content at 70 DAS were made on five randomly selected plants in each treatment plots. Third leaf from the top was collected for the estimation of total chlorophyll content (ppm). The analysis of variance was done as suggested by Panse and Sukhatme (1985) [7].

Results and Discussion

The results summarized in Table 1 revealed that foliar application of growth regulating substances had significant impact on number of effective tillers, plant height and chlorophyll content. In pooled analysis, number of effective tillers at 70 DAS found increased significant with T_7 *i.e.* 2.63 and it was at par with T_6 (2.47) and T_5 (2.31) where days to 50% flowering recorded significantly differ among different treatment every year but in pool analysis it was recorded with non-significant differences. Plant height and chlorophyll content at 70 DAS were also significantly affected with application of growth regulating substances in all individual years as well as in pool analysis. Improvements in morpho-physiological parameter contributed to grain yield and its attributing characters. Foliar application of growth regulating substances improves the vegetative growth at latter phase of pearl millet crop under rainfed condition.

Table 1: Effect of foliar spray of plant growth substances on number of effective tillers, days to 50% flowering and plant height at harvest at 70 DAS of pearl millet

	Treatment	Number of effective tillers				Days to 50% flowering				Plant height at harvest (cm)				Chlorophyll content			
		2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled
1.	Untreated control	1.10	1.70	2.25	1.68	39.25	55.25	47.75	47.42	135.8	135.4	151.3	140.8	1.34	2.35	2.45	2.05
2.	Distilled water	1.13	1.65	2.50	1.76	39.50	53.25	49.00	47.25	138.6	139.8	155.8	144.7	1.43	2.61	2.41	2.15
3.	Thiourea 1000 ppm	1.38	1.75	3.25	2.13	37.75	54.00	44.75	45.50	137.5	142.7	137.5	139.2	1.54	2.64	2.77	2.32
4.	Benzyl adenine 25 ppm	1.38	2.05	2.75	2.06	37.75	56.00	47.75	47.17	133.9	132.8	134.8	133.8	1.79	2.75	2.49	2.34
5.	Benzyl adenine 50 ppm	1.73	1.95	3.25	2.31	38.50	53.00	48.00	46.50	131.8	134.3	135.3	133.8	1.70	2.25	3.08	2.34
6.	Potassium chloride 0.75%	1.75	2.15	3.50	2.47	37.25	52.00	47.75	45.67	135.7	137.6	140.5	137.9	1.82	3.33	3.22	2.79
7.	Potassium chloride 1.50%	2.00	2.15	3.75	2.63	37.00	52.50	48.25	45.92	141.6	143.6	148.3	144.5	2.00	2.98	3.20	2.72
	S.Em.±	0.17	0.19	0.24	0.12	0.45	0.42	0.40	0.70	2.47	1.93	2.10	2.50	0.03	0.12	0.02	0.12
	C.D. at 5%	0.52	NS	0.72	0.33	1.33	1.24	1.19	NS	NS	5.75	6.23	7.70	0.08	0.37	0.06	0.38
	C.V. %	23.43	19.71	15.94	18.99	2.35	1.55	1.69	1.82	3.62	2.80	2.93	3.13	3.34	9.20	1.52	6.24
Y	S.Em.±				0.08				0.46				1.63				0.08
	C.D. at 5%				0.22				1.41				5.04				0.25
YXT	S.Em.±				0.20				0.42				2.18				0.07
	C.D. at 5%				NS				1.20				6.18				0.21

Threshing index, harvest index, test weight & days to maturity were analyzed as yield attributing characters to evaluate the effect foliar application of growth regulating substances for enhancing grain seed (Table 2). The threshing index was recorded with significantly higher with T_7 in the year 2016 as well as in the pooled analysis, but during 2014 there was no significant difference among treatments. Harvest index was found significantly higher with T_7 in all the years and in pooled data (35.99%) except 2015 (35.74%) where it was significantly higher with T_3 *i.e.* application of thiourea 1000 ppm. Data regarding 1000 seed weight (g) revealed that it was significantly higher with T_7 in all the years and in pooled data (9.71g) and days to maturity found with non-significant differences in pooled analysis.

Table 2: Effect of foliar spray of plant growth substances on threshing index, harvest index, 1000 seed weight and days to maturity of pearl millet

No.	Treatment	Threshing index (%)				Harvest index (%)				1000 seed weight (g)				Day to maturity			
		2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled
1.	Untreated control	64.11	55.95	58.18	59.41	27.26	30.42	29.83	29.17	7.65	7.73	7.80	7.73	70.50	85.00	78.25	77.92
2.	Distilled water	62.55	55.71	65.41	61.22	26.74	30.96	32.62	30.11	8.59	8.73	8.78	8.70	71.25	83.00	78.00	77.42
3.	Thiourea 1000 ppm	65.12	66.50	70.23	67.28	29.15	35.74	35.86	33.58	9.03	9.56	9.62	9.40	71.25	84.00	76.00	77.08
4.	Benzyl adenine 25 ppm	64.92	63.24	69.50	65.88	27.72	33.98	34.60	32.10	8.95	9.28	9.37	9.20	70.75	85.50	77.50	77.92
5.	Benzyl adenine 50 ppm	67.65	65.99	71.82	68.49	29.89	35.08	35.77	33.58	9.18	9.43	9.50	9.37	71.00	83.25	80.00	78.08
6.	Potassium chloride 0.75%	71.17	67.23	71.96	70.12	31.16	35.72	35.98	34.29	9.23	9.61	9.60	9.48	70.75	82.00	78.00	76.92
7.	Potassium chloride 1.50%	76.69	64.67	78.95	73.43	33.21	35.07	39.68	35.99	9.44	9.85	9.85	9.71	70.50	82.50	78.25	77.08
	S.Em.±	4.03	1.91	3.41	1.87	1.38	1.05	1.64	0.80	0.22	0.08	0.09	0.08	0.57	0.38	0.44	0.64
	C.D. at 5%	NS	5.68	10.12	5.31	4.11	3.11	4.86	2.26	0.64	0.24	0.27	0.23	NS	1.14	1.29	NS
	C.V. %	11.95	6.09	9.81	9.74	9.45	6.18	9.38	8.43	4.86	1.73	1.94	3.13	1.62	0.92	1.12	1.21
Y	S.Em.±				1.22				0.52				0.05				0.42
	C.D. at 5%				3.47				1.48				0.15				1.29
YXT	S.Em.±				3.24				1.38				0.14				0.47
	C.D. at 5%				NS				NS				NS				1.34

Grain yield was found significantly highest during the year 2014, 2015 and 2016 with foliar application of potassium chloride 1.5% (Table 3). In pooled analysis, potassium chloride 1.50% (3138 kg/ha) also recorded significantly higher yield in comparison to other treatments along with control. The data regarding fodder yield revealed that there was found significantly highest during the year 2014, 2015 and 2016 with foliar application of potassium chloride 1.5% (T_7) whereas, in pooled analysis T_7 (4536 kg/ha) was also recorded significantly higher yield in comparison to other treatments along with control. Ear head weight found significantly highest during the year 2013, 2014 and 2015 with foliar application of potassium chloride 1.50% (T_7). It was also recorded significantly higher in pooled analysis (4307 kg/ha) in comparison to other treatments along with control. The data regarding total dry matter yield revealed that there were significant differences among treatments for all the years and pooled results. In pooled analysis, T_7 (8844 kg/ha) was recorded significantly higher than other treatments along with control.

Table 3: Effect of foliar spray of growth regulating substances on grain, fodder, ear head and total dry matter yield of pearl millet

No.	Treatment	Grain yield (kg ha^{-1})				Fodder yield (kg ha^{-1})				Ear head weight (kg ha^{-1})				Total dry matter yield (kg ha^{-1})			
		2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled
1.	Untreated control	2088	2178	1785	2017	4417	3255	2926	3532	3308	3895	3068	3424	7725	7152	5994	6957
2.	Distilled water	2298	2287	2164	2249	4875	3279	3326	3827	3721	4103	3328	3717	8596	7383	6653	7544
3.	Thiourea 1000 ppm	2621	2824	2413	2619	4958	3673	3312	3981	4038	4256	3445	3913	8996	7931	6758	7895
4.	Benzyl adenine 25 ppm	2450	2720	2354	2508	5042	3702	3417	4053	3804	4309	3393	3835	8846	8012	6809	7889
5.	Benzyl adenine 50 ppm	2706	2832	2506	2681	5042	3777	3512	4110	4013	4296	3540	3949	9054	8074	7051	8060
6.	Potassium chloride 0.75%	2888	2960	2538	2795	5250	3890	3527	4222	4083	4417	3524	4008	9333	8310	7051	8231
7.	Potassium chloride 1.50%	3450	3079	2885	3138	5917	4052	3641	4536	4496	4769	3657	4307	10413	8822	7298	8844
	S.Em.±	127.33	102.52	86.38	61.63	268.50	167.37	124.72	113.36	220.45	164.01	123.77	100.45	379.81	319.40	171.28	174.99
	C.D. at 5%	378.34	304.62	256.66	174.84	797.77	497.31	370.58	321.60	655.03	487.31	NS	284.98	1128.5	949.03	508.91	496.44
	C.V. %	9.64	7.60	7.27	8.30	10.59	9.14	7.38	9.73	11.24	7.64	7.23	8.97	8.45	8.03	5.04	7.66
Y	S.Em.±				40.35				74.21				65.76				114.56
	C.D. at 5%				114.46				210.54				186.56				325.00
YXT	S.Em.±				106.75				196.35				173.99				303.10
	C.D. at 5%				NS				NS				NS				NS

Gross realization, cost of cultivation, net realization and B:C ratio of different treatments were worked out on the basis of current market prices of pearl millet grain and fodder and inputs used (Table 4). The results indicated that net return (Rs. 27245 /ha) was maximum with foliar application of potassium chloride 1.5% (T_7) at tillering (30-35DAS) and post-anthesis stage (50-55DAS) along with B:C ratio 1.16. Shivkumar and Krishna (2020) reported that foliar spray of potassium chloride 1% + benzyl amino purine 50 ppm registered highest root length (17.2 cm), leaf area (425.3 cm2), leaf area index (1.82) and leaf area duration (55.7 days) compared to other treatments in finger millet. Parihar *et al.* (1998) [8] reported that foliar spray of 1000 ppm thiourea at pre-flowering stage of pearl millet significantly enhanced the crop growth and dry matter as compared to water sprayed control plants. Jagetiya and Kaur (2006) [6] also stated that foliar spray with 2000 ppm of thiourea increased chlorophyll content, shoot dry weight and final weight per 100 seeds by delaying senescence and improving photosynthetic capacity in soybean. Abou Aziz *et al.* (2011) registered that application of benzyl adenine significantly increased the SLW compared to the control. The increase in the SLW by benzyl adenine could be due to stimulating dry mass production through enhancement of cell division and chlorophyll accumulation which leads to higher photosynthetic activity and accumulation of dry matter.

Table 4: Economics of different treatments in pear millet

Treatment	Grain yield (kg ha^{-1})	Fodder yield (kg ha^{-1})	Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
Untreated control	2017	3532	33536	14591	18945	1.30
Distilled water	2249	3827	37227	17091	20136	1.18
Thiourea 1000 ppm	2619	3981	42638	15991	26647	1.67
Benzyl adenine 25 ppm	2508	4053	41192	17275	23917	1.38
Benzyl adenine 50 ppm	2681	4110	43699	19459	24240	1.25
Potassium chloride 0.75%	2795	4222	45463	19291	26172	1.36
Potassium chloride 1.50%	3138	4536	50736	23491	27245	1.16

Prices: Grains Rs. 14/kg, fodder Rs. 1.5/kg, Labour charge Rs. 250/day, Water used to prepare solution @500 L ha^{-1}

From the present investigation it is evident that foliar spray of plant growth retardants at tillering and post-anthesis stage influenced growth and yield attributing traits *viz*., grain yield, ear head weight, total dry matter, threshing index, harvest index, test weight, number of effective tillers were significantly higher. Finally, among all the treatments, foliar application of potassium chloride 1.5% (7.5 kg/ha in 500 liter water) at 30-35 and 50-55 DAS for proper vegetative growth and to get higher seed yield and net return.

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