Canopy Temperature Depression and its Effect on Seed Set and Seed Yield of Sewan Grass (*Lasiurus sindicus* L.)

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Rangelands or grazinglands are extensive tracts of arid and semi-arid lands that are essentially unsuited to rain-fed crop cultivation, industrial forestry, protected forests or urbanization. More than 200 million people use rangelands over the world for some pastoral production, whereas 30 to 40 millions of these people are wholly dependent on livestock. The grasses assume importance not only as livestock feed, but also as soil builders and binders and aid in soil conservation. In their principal role, the tropical grasses stand as the highest potential yielder of starch and proteins equivalent to any other crop plants and further being the dominant component of tropical pastures, as the cheapestsources of animal feed (Rajoraet al. 2002). Perennial grass speciesof arid grasslands such as *Cenchrusciliaris, Cenchrussetigerus, Lasiurussindicus, Dichanthiumannulatum, Panicumantidotale*and *Sehimanervosum* are grouped as high perennial species as they give high forage yield under natural rain-fed conditions. *L. sindicus* is a valuable tufted perennial grass in arid areas characterised withdrought and high temperature tolerance, suitable for low rainfall and sandy soil. It is an excellent grazing perennial suited to pasture and rangelands. Its high soil binding capacity is due to its clustered root system in the upper 8 to 10 cm layer of soil. The only problem with *L. sindicus*is its poor seed yield. The poor seed set and seed shattering rate due to its higher canopy temperature are possible causes of its poor seed yield.ThePlant growth regulators(PGRs) have been evaluated widely in temperate grass seed crops, with their application often resulting in large increases(50-136%) in seed yield (Rolston *et. al*, 1997). Research during the 1980s and 1990s was based mainly on the use of soil-application triazole PGRs particularly paclobutrazol, that reduced stem length and lodging and improved seed yields in a range of temperate grass species (Rolston *et. al*, 1997).The present study also aimed on use of different levels of hormones for improving seed set and seed yield of Sewan grass.

The experimental site located at Experimental Area, Chandan, CAZRI, RRS, Jaisalmer, Rajasthan, India (latitude 26Ú 59' 31.32 N and longitude 71Ú 20' 29.59 E) having elevation of196 meters (640 feet)is 40 kmaway from golden city Jaisalmer.The experimental area, Chandan received 164.5 mm rainfall during the year 2013 against the average rainfall (157 mm). The soil of the experimental site was sandy loam and slightly alkaline (pH 7.5) with 0.36% organic carbon, electrical conductivity- 0.16mmho, available nitrogen :285 kg/ha, available phosphorus: 24 kg/ha, available potash : 356 kg/ha.The study was conducted during the year 2013-2014. The plots size was 20 x 6 m and distance between the adjacent plots was 1 m and a hundred tussocks were planted in each plot according to the row method, with a spacing of 1 x 1 m. Different levels of plant hormones [T_1- Control (water); T_2- Cycocel (100 ppm), T_3– Cycocel (200 ppm), T_4– Paclobutrazol (200 ppm), T_5 – Paclobutrazol (400 ppm), T_6 – Cycocel (100 ppm) + Paclobutrazol (200 ppm), T_7 – Salicylic acid (100 ppm) and T_8 – Salicylic acid (200 ppm)] were sprayed at pre-flowering and anthesis stages on the Sewan grass planted in RBD design with three replications. Routine agronomic practices of fertilizer and irrigation were followed. The meteorological data, namely average maximum and minimum temperature, humidity, photoperiod, wind speed, wind direction and rainfall were noted during the field experiment. Ten plants were randomly selected and growth data were recorded at weekly interval from all sets. Three cuts of grasses were taken and the growth data included number of raceme, number of tillers, tussock diameter, plant height, above ground biomass (fresh and dry) and below ground biomass (fresh and dry) weight per plant were taken at weekly intervals. The total phenol content of the leaf and stem were estimated following the method of Malik and Singh (1980) while

the sugar was estimated with the m*et*hod of Dubois *et al*. (1951).

The m*et*eorologic*al* data recorded during the period of experiment after given hormones treatment showed that the minimum atmospheric temperature varied from 21.0–27.0 ^{0}C while the maximum varied from 35.0-42.0^{o}C. The 18.3 to 28.4mm variation in vapour pressure and 29 to 81% variation in relative humidity were *al*so recorded during the period (Table 1). The tot*al* rainf*al*l received during 2013 was 164.5mm, out of which 127.5mm received during July and August. Sunshine hours recorded during observation period varied from 2-10 hours. Canopy temperature (CT) recorded under study showed increasing trend in the dayupto noon and then declined slowly. The CT recorded in control plot was higher than that of atmospheric and soil temperature. The application of different hormones and its levels significantly reduced CT of sewan grass and the level of this reduction *al*so varied with different hormones. The maximum decrease in CTas compared to control was recorded with T_6 (Fig. 1). Canopy temperature depression (CTD) is an easily measured manifestation of crop m*et*abolic and physiologic response to the environment. Among other things, CTD can be used to distinguish stress-tolerant from stress-intolerant ones. Norm*al*ly the v*al*ue of CTD is positive,but in our case negative CTD was recorded in sewan grass mainly because of high CT. The hormones application improved CTD and its v*al*ue got raised (Fig 2). The maximum higher v*al*ue of CTD was recorded with T_6 (Cycocel (100 ppm) + Paclobutrazol (200 ppm).

The phenol content varied from 1.47 to 4.7 (mg/g fresh weight) in leaves and 4.6 to 9.0 7 (mg/g fresh weight) in stem (Table 2). The control plant shows

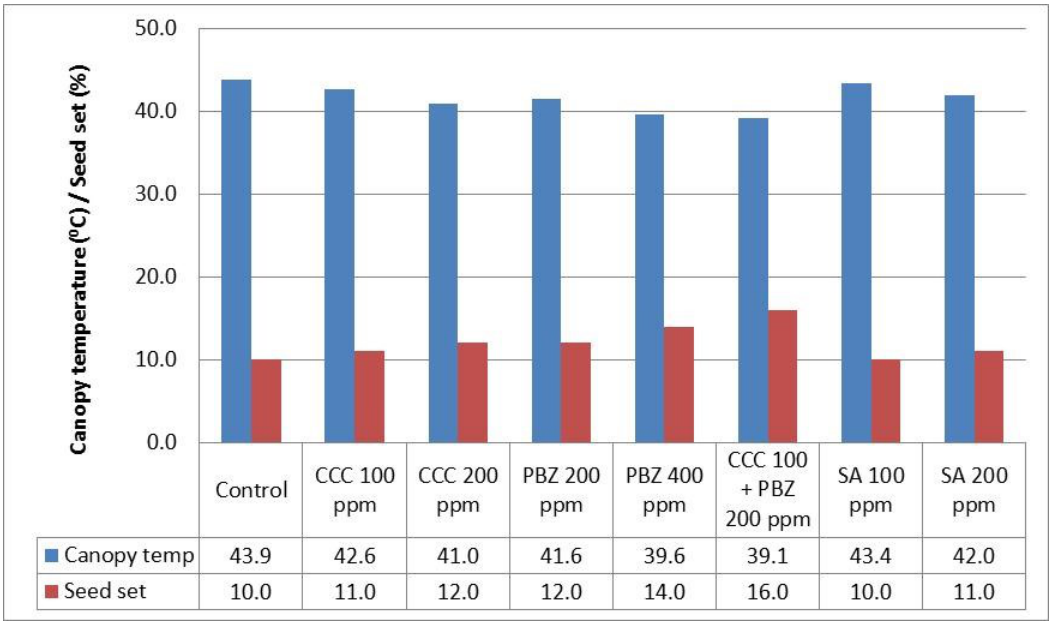
Table 1. Average of different meteorological parameters recorded at different time interval.

Weekly mean/ Interval	Sunshine hours	Parameter				
		Atm. Temperature (^{0}C)	Soil Temperature (^{0}C)	Canopy Temperature (control)	Canopy Temperature (Best treatment)	Wind Speed (km/hr.)
10/09/13	7.8	37.1	41.8	45.1	40.0	11.0
17/09/13	9.0	39.1	44.5	44.2	39.0	2.8
24/09/13	8.4	37.4	40.2	43.7	38.3	3.6
01/10/13	8.6	36.1	39.1	43.3	37.7	4.8
08/10/13	7.8	37.1	40.7	43.9	39.1	1.4

Table 2. Range, mean and C.V of different growth, biochemical and yield characters of sewan grass (*Lasiurus sindicus* L.) along with CTD and canopy temperature at different stages.

	10/09/2013			17/09/2013			24/09/2013			01/10/2013		
Characters	Range	Mean±S.E	C.V	Range	Mean±S.E	C.V	Range	Mean±S.E	C.V	Range	Mean±S.E	C.V
Av. Canopy temp.	40.0-45.1	42.5±0.6	3.1	38.9- 41.2	41.8±0.6	3.2	38.3- 43.7	41.2±0.7	3.5	37.7- 43.4	40.7±0.7	3.9
CTD	-8.1- -3.0	-5.5±0.6	24.4	-5.1- 0.2	-2.71±0.6	49.7	-6.3- 0.9	-3.85±0.7	37.2	-6.2- 0.6	-3.64±0.7	43.1
Root:Shoot length	0.33-0.5	0.4±0.02	10.1	0.34-0.5	0.41±0.02	9.0	0.39-.50	0.44±0.01	6.7	0.40-0.5	0.45±0.01	6.4
No. of Raceme	75-120	98.9±5.53	13.2	89-125	106.0±4.41	9.8	97.0-132	115±4.14	8.1	105-135	120±3.64	7.0
Spikelets/raceme	32-53.7	40.7±2.52	14.4	38.5-56.6	45.8±2.03	9.68	41-59	48±2.06	8.9	43-63	51±2.13	8.77
Spike length	9.63-14.8	11.0±0.7	12.5	9.2-14.9	11.05±0.7	12.7	10.3-16.2	12.6±0.8	13.8	10.7-18.2	13.9±1.0	16.5
Tussock diameter	21.9-35.8	28.2±1.7	14.6	22.2-38.9	30.0±2.1	15.8	23.3-40.3	31.3±2.1	15.0	24.2-42.2	33.6±2.2	15.2
Tillers/tussock	89-146	119.0±7.5	15.1	94-152	123.4±7.5	13.9	96-155	125±7.3	13.4	101-157	128±7.0	12.4
GFY	0.78-1.2	0.9±0.05	8.65	0.82-1.32	1.01±0.05	11.1	0.85-1.42	1.10±0.06	12.3	0.87-1.52	1.17±0.07	11.8
DFY	0.35-0.60	0.4±0.02	11.6	0.39-0.64	0.49±0.03	11.7	0.42-0.71	0.56±0.03	11.1	0.51-0.82	0.65±0.04	12.5
WSD	0.58-0.7	0.62±0.01	3.6	0.56- 0.6	0.58±0.01	2.5	0.52- 0.6	0.55±0.01	3.7	0.50- 0.5	0.53±0.01	2.7
RWC	0.40-0.5	0.40±0.01	5.2	0.35- 0.4	0.40±0.01	6.6	0.32- 0.4	0.36±0.01	8.0	0.31- 0.4	0.35±0.01	5.7
Seed yield	2.50-4.8	3.5±0.3	17.8	2.10 - 5.2	3.83±0.3	18.3	3.1- 5.7	4.30±0.3	17.3	5.20- 8.6	7.04±0.4	13.2
Phenol in leaf	-	-	-	1.47- 4.6	2.71±0.4	30.6	1.7- 4.7	3.16±0.4	31.2	-	-	-
Phenol in stem	-	-	-	5.83- 7.6	6.83±0.2	7.3	4.6- 9.0	7.19±0.6	16.5	-	-	-
Sugar in leaf	-	-	-	4.13- 6.6	5.36±0.4	16.6	3.8- 9.2	6.09±0.7	24.1	-	-	-
Sugar in stem	-	-	-	6.74- 21.4	13.2±1.7	25.9	10.4- 21.0	15.7±1.3	18.5	-	-	-

*WSD- Water saturation deficit; RWC- Relative water content; DFY- Dry fodder yield; ACT- Actual canopy temperature; CTD- Canopy temperature depression



	Control	CCC 100 ppm	CCC 200 ppm	PBZ 200 ppm	PBZ 400 ppm	CCC 100 + PBZ 200 ppm	SA 100 ppm	SA 200 ppm
Canopy temp	43.9	42.6	41.0	41.6	39.6	39.1	43.4	42.0
Seed set	10.0	11.0	12.0	12.0	14.0	16.0	10.0	11.0

Fig. 1. Effect of different level of hormones on canopy temperature and seed set (%) of *Lasiurus sindicus*

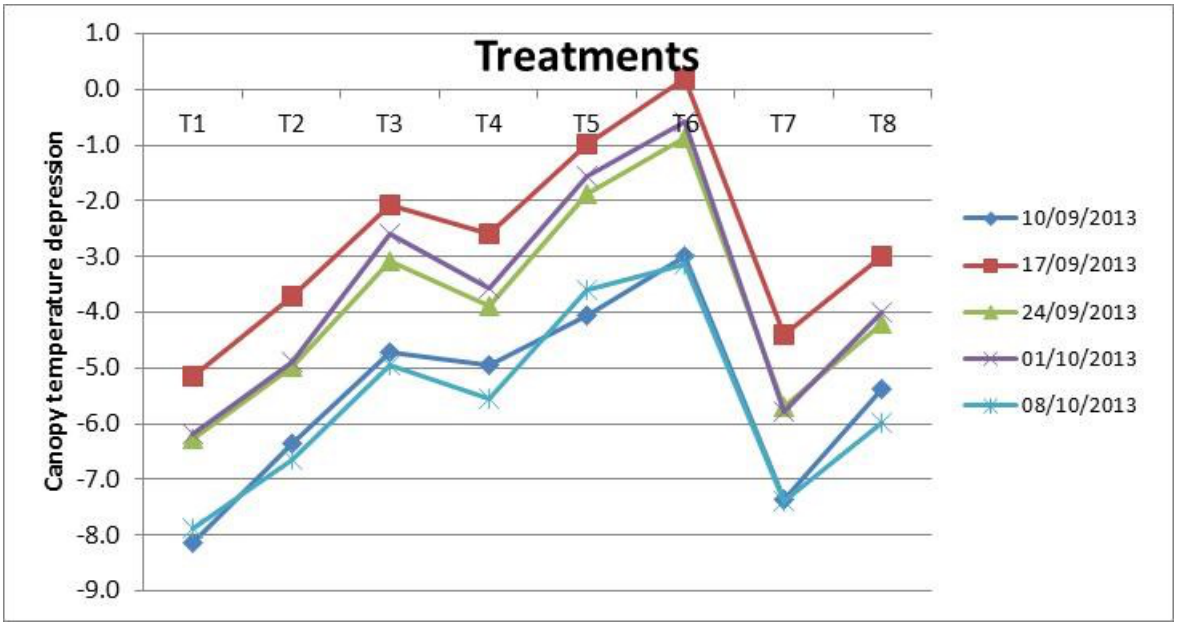


Fig. 2. Effect of different level of hormones on canopy temperature depression (CTD) at different time intervals

minimum phenol content while the application of hormones increases its level significantly over the control. The maximum 125% increase in leaf phenol and 95% increase in stem phenol over control were estimated with T_6. Similar to phenol, maximumincreases in sugar content was *al*so observed in leaf (142) and stem (88mg/g fresh weight) of T_6 treated plant as compared to control.The CTD had significant positive relationship with tot*al* phenol and sugar content of leaves and stem as shown in Fig 3. The lower v*al*ues of CTD favoured high phenol and sugar content. The phenol and sugar content may play some role in seed s*et* and seed yield.

The relative water content (RWC) varies from 31.7 to 54.5%. The lower RWC in the leaves of control plants were significantly increased with the application of different level of hormones that maintained higher relative water content of leaves (40 – 72%) and lower water saturation deficit (18.6 - 33.3%) as compared to control (31.7 and 68.3 respectively) as shown in Table 2.

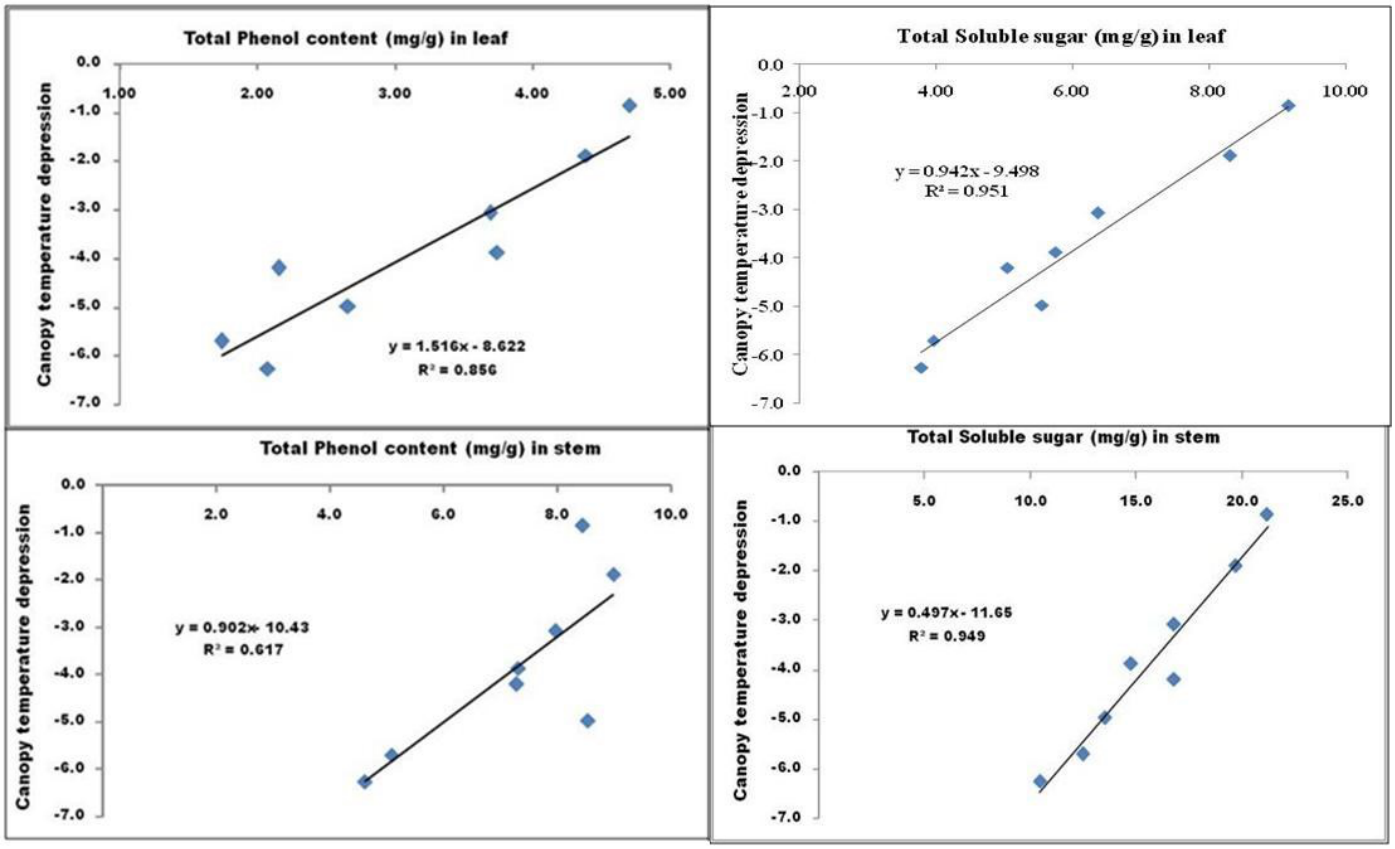


Fig 3. Relationship of canopy temperature depression (CTD) with total phenol and sugar content of leaves and stem of Lasiurus sindicus treated with different hormones.

Further, the CT in control plants was recorded 5-6^{0}C higher than that of atmospheric temperature. However, the application of hormones reduced the canopy temperature and the minimum canopy temperature (39^{0}C) *al*ong with high relative water content (54.5%) was recorded in plants treated with T_6.

The growth data (Table2) showed the gradu*al* increase intussock diam*et*er, tiller/tussock, root:shoot length ratio, number of raceme, spikel*et*/raceme and spike length with the stage advancement.The maximum tussock diam*et*er (23.3-40.2 cm^2), tiller number (96-155), raceme number (97-132), spikel*et*/raceme (41-58) were measured at 4th week of the treatment application with the mean v*al*ues of 31.3 cm, 125, 115, 48, respectively (Table 2). The significant increase in these param*et*ers was recorded with theapplication of different levels of hormonesover the control. Cycocel 200 ppm increase tussock diam*et*er by 54.1%, tiller numbers by 43.5%, and spike length by 43% over the control. Cycocel was found more effective with paclobutrazol and the 100ppm CCC with 200 ppm paclobutrazolgave b*et*ter results and they showed highest 74.4% increase in tussock diam*et*er, 55.4% increase in tiller numbers, 104% increase in raceme number and 70% increase in spike length. The green fodder and dry fodder yield of sewan grass was *al*so increased with the foliar application of hormones. The combination of CCC (100 ppm) and paclobutrazole (200 ppm) was found more effective than the other treatments.

The per cent seed s*et* and pure seed yield was improved by the application of different level of hormones over control and maximum seed yield (8.6g/ plant) was recorded in the plants sprayed with T_6followed by T_5 (8.0 g/plant).The paclobutazol and s*al*icylic acid were *al*so found effective to improve the sewan grass growth through improving these param*et*ers.Inflorescence number and seed yields, in particular, were affected, with quite large differences b*et*ween means. In addition, a combination of growth stage, soil nitrogen, temperature and relative humidity has been shown to produce variable results when PGRs are applied (Mathiassen *et al*., 2007). Two different studieshave reported increases in seed yield of tropic*al* grasses from using PGRs. In the first study,

applying paclobutrazol (750g/ha a.i.) at early seed head emergence increased seed yield of *Digitariaeriantha* from 305kg/ha (control) to 462kg/ha(Ramirez and Hacker, 1993). While applying paclobutrazol before seed head emergence reduced seed yield by nearly 30%. In another study, a commerci*al* steroid*al* phyto-hormone, cidef-4, significantlyincreased seed yield of P.maximum irrespective of stage of application (Joaquin *et. al*., 2007).These positive responses in seed yield were optimized when PGRs were applied at seed head-emergence (Zadoks growth stages 50-55) or early anthesis stage.The lower seed s*et* could be due to pollen sterility as Risso-Pascotto *et. al*. (2005) found that more than 65% of pollen grains on *Brachiaris* inter-specific hybrids were sterile and that this sterility was gen*et*ic.

Despite from its utility for hot arid ecosystem, the poor seed s*et*, seed shattering and lower seed yield are the major constraint for its wide spreading in the region. The high canopy temperature, high hot wind and lower CTD are the possible reasons for poor seed yield.The application of different hormones improved water content of leaves as shown from high relative water content lower down canopy temperature and increase CTD. It *al*so has significant effect on tot*al* phenol and sugar content. The application of hormonesimproved the seed s*et* and seed yield may be because of high relative water content and change in m*et*abolites composition as shown from the phenol and sugar content. The study need further focus on Biochemic*al* aspect in relation to canopy temperature depression and other m*et*eorologic*al* param*et*ers.

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