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IMPACTS OF WINTER RAIN ON OLEORESIN PRODUCTION OF *COMMIPHORA WIGHTII* (ARNOTT.) BHANDARI IN CHAMBAL RAVINE, CENTRAL INDIA

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Abstract- *Commiphora wightii* (Arnott.) Bhandari is found in the semi arid and arid regions of India. Over exploitation of this species for its Oleoresin has led to its decline in their natural stand. During the guggul tapping season in the year 2013-14, the abiotic stress was less in comparison to that in the year 2012-13. Less abiotic stress due to winter rain on the guggul production in Chambal ravines. The mean production of guggul gum during the year 2012-13 was 385.30 g, while it was 145.59 g during 2013-14. Thus the mean gum production per plant declined by 62.61 percent during 2013-14, besides this the viscosity of the guggul gum was affected due to winter rain during 2013-14. Those plants tapped before rains produced comparatively more gum, similarly the proportion of tapped trees damaged was higher than those with untapped trees during the year. Gum production was positively correlated with temperature while rainfall was negatively correlated with other variables during both the year. Tapping of Guggul in ravines is carried out from last week of February to March, was delayed by one week during 2013-14. The delay was due to low temperature and high humidity during the tapping period.

Keywords- Oleoresin, Metabolites, Guggul, Abiotic stress

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Introduction

Commiphora wightii (Arnott.) Bhandari is a medium size plant family Burseraceae is found in the semi arid and arid regions of Gujarat, Rajasthan and Madhya Pradesh in India [1]. The oleo resin produced by *C wightii* is used in numerous ayurvedic medicines [3]. Over exploitation and lack of conservation of *C wightii* has led to its continuous decline in the natural stand, leading to be categorized as 'data deficient' category ver. 2.3 of the Red Data Book. However, the Government of India has included it under RET (Rare, Endangered, Threatened) category [4]. This RET category plant in India [5];[6] has medicinal, ecological and economical importance [1]. In Central India, the natural stand of *C wightii* is found in the Chambal ravines [7], where a rapid decline in its population is observed. A decline in guggul gum production in recent years in India is reported by [8]. *C wightii* is tapped for the oleoresin between February to March, when the weather is dry and hot that creates abiotic stress in the plant. Environmental stresses is reported to cause drastic changes in the growth, physiology and metabolism of plants leading to the increased accumulation of secondary metabolites in plants [9,10]. Secondary metabolites play a major role in the adaptation of plants to the environment and in overcoming stress conditions. Frequent winter rains between December 2014 and April 2015, in the Chambal ravines have minimized the usual abiotic stress essentially required for during crucial tapping period of *C wightii*. The present study was to explore the impact of winter rain on oleoresin production in *C wightii*.

MaterialsandMethods

Chambal ravines are geographically located at located between 26°18'N longi 78°00'E lati and 26.30°N longi 78.00°E lati in the plateau of Central India in the northern part of Madhya Pradesh. There are six districts in the ravines including Morena with natural stand of *C wightii*. Guggul is tapped by Malhar (boat men) community, residing on the banks of river Chambal. Though there is no official restriction, yet Malhars consider tapping of guggul illegal do not disclose information until taken into confidence. Seventeen people associated with guggul tapping in seven village of Morena district were interacted for collection data, with the help of local NGO- Sujagrati Samaj Sewa Sansthan, Morena. The weather data for the year 2012-13 and 2013-14 was collected from the Zonal Agriculture Research Station, Morena, during [Table-1]. The relationship between yield, tapping time, rainfall, maximum and minimum temperature and relative humidity were examined using simple correlation analysis [Table-3 and 4].

Results and Discussion

During the guggul tapping season of the year 2013-14, the abiotic stress was comparatively less than during the year 2012-13, as evident from the [Table-1]. Less abiotic stress due to 29 rainy days between December 2013 to March 2014 in Chambal ravines.

Impact of winter rain on Guggul gum production (quality and quantity)

The mean production of guggul gum per plant during the year 2012-13 was 385.30 g (341.18 to 429.42 g), while it was 145.59 g (123.53 to 167.65 g) per plant during 2013-14. Thus, the mean decline gum production per plant was 62.61 percent during 2013-14 over 2012-13. Besides the decline in guggul gum yield, the viscosity of the guggul gum was affected due to winter rain during 2013-14 [Table-2]. On incision, the oozing of guggul was comparatively faster in 2013-14 probably due to less viscosity of the gums while this was not the case during 2012-13. Frequent rain during tapping season reduced the gum viscosity [11]. The decline in the production was due to rainfall during the months of December 2013, January to April 2014. The drought-induced water deficit stress in plants is the result of complex relationship between soil, plant and environment [12]. The winter rain in Chambal ravines reduced the usual climatic (abiotic) stress. Guggul plant tapped before rains in February 2014 produced more gum than those tapped in March 2014 [Table-2]. It was also observed that the proportion of trees damaged was comparatively higher in among tapped trees than those in untapped trees.

Tapping exposes the tree for attack by pests and other damages [13]. In the present case the damage was due to excess rain during tapping period, which was unusual. Gum production was positively correlated with maximum temperature (r=0.34), minimum temperature (r=0.31), pan evaporation (r=0.17) and wind speed (r=0.25) similar kinds of results observed by [16] but gum production was negatively associated with relative humidity of morning (r=-0.46) and evening (r=-0.65) as well as rainfall (r=-0.23) during the year of 2012-13 [Table-3]. Guggul gum production in 2013-14 declined by 62.61 percent as compared to 2012-13 and it was positively correlated with maximum temperature (r=0.17) while negatively associated with minimum temperature (r= -0.06), relative humidity morning (r=-0.35) and evening (r=-0.07), rainfall (r=-0.50), pan evaporation (r=-0.30) and wind speed (r=-0.69) [Table-4]. Pan evaporation was highly and significantly associated with wind speed (r=0.99**, r=0.89) during the year of 2012-13 and 2013-14 respectively. The sharp decrease of the environmental relative humidity and increase the temperature during tapping period of gum yielding plants were suitable for influence gum yield [8].

Table-1 *Weather data during tapping period of C wightii in Morena district (2012-13 and 2013-14)*

Month	Temperature (ºC)						Relative humidity (%)						Rainfall (mm)			Pan evaporation (mm)			Wind speed (km/hrs)		
	2012-13	2013-14	Dif	2012-13	2013-14	Dif	2012-13	2013-14	Dif	2012-13	2013-14	Dif	2012-13	2013-14	Dif	2012-13	2013-14	Dif	2012-13	2013-14	Dif
	Maximum			Minimum			Morning			Evening											
Dec	24.74	24.58	0.16	8.56	9.82	1.26	80.06	78.68	1.38	64.00	62.30	1.70	0.00	17.50	17.50	2.61	1.88	0.73	2.82	1.12	1.70
Jan	20.90	16.30	4.60	6.32	6.75	0.43	84.26	90.10	5.84	70.65	77.80	7.15	0.48	17.25	16.77	1.89	0.70	1.19	2.35	1.50	0.85
Feb	22.96	19.55	3.41	9.11	9.05	0.06	81.71	84.88	3.16	65.54	67.45	1.91	1.60	4.67	3.07	2.46	2.78	0.31	2.88	2.28	0.60
March	32.74	29.62	3.12	14.56	13.72	0.84	74.52	76.12	1.60	59.81	50.04	9.77	0.05	8.73	8.68	6.89	5.36	1.53	4.56	3.08	1.48
April	37.98	34.26	3.72	21.88	19.60	2.28	47.69	53.67	5.98	35.41	37.67	2.25	0.34	1.23	0.89	11.22	8.62	2.61	7.19	5.34	1.85
Mean	**27.87**	**24.86**	**3.00**	**12.09**	**11.79**	**0.30**	**73.65**	**76.69**	**3.04**	**59.08**	**59.05**	**0.03**	**0.49**	**9.88**	**9.38**	**5.02**	**3.87**	**1.15**	**3.96**	**2.66**	**1.30**

Table 2: Impact of winter rain on Guggul plants and its productivity in Chambal ravines of Morena district

S. no	Name		2012-13				2013-14				Remarks
	Guggul collectors	Village	Tapping time	Guggul production/plant		Plant health	Tapping time	Guggul production/plant		Plant health	
				Quantity (g)	Quality			Quantity (g)	Quality		
1	Ram Nivash	Purani useth	10th March	400-500 (450)	Thick	Normal	3rd April	200-250 (225)	Less viscous	Improved plant health as compared to last year	Time of tapping was delay around one week as compared to 2013-14. It was happened due to low temperature and high humidity during tapping time and also decreased production of Guggul. Plants that were not tapped were more healthy than tapped
2	Vanti	Purani useth	13th March	400-500 (450)	Thick	Normal	27th March	200-250 (225)	Less viscous		
3	Jeetu	Purani useth	13th March	400-500 (450)	Thick	Normal	4th April	200-250 (225)	Less viscous		
4	Zakir Hussain	Morena	17th March	250-300 (275)	Thick	Normal	11th April	100-150 (125)	Quality low as compared to 2012-13	Over vegetative growth cause of rain and humidity	
5	Gopal	Useth	15th March	400-500 (450)	Thick	Normal	21st March	200-250 (225)	Loose thickness of gum as compared to 2012-13	Plants health improved	
6	Ram Kishan	Useth	5th March	400-500 (450)	Thick	Normal	7th April	150-200 (175)	Loose thickness of gum as compared to 2012-13	Little improvements was shown by plants as compared to last year	
7	Uday Singh	Useth	12th March	250-350 (300)	Thick	Normal	23rd March	50-100 (75)	Thin		
8	Raju	Useth	18th March	300-350 (325)	Thick	Normal	28th March	00-00 (00)**	Weight loss of guggul gum	Improved plants health in which tapping was not done.	
9	Buddh Singh	Useth	13th March	300-400 (350)	Thick	Normal	23rd March	150-200 (175)	Weight loss of guggul gum	Improved plant health because of the rain.	Tapping was done before rain they plants were produced more Guggul gum. Tapping done after rain plants produced less gum but plants health has improved as compared to 2013-14.
10	Raghvendra	Useth	15th March	300-400 (350)	Thick	Normal	23rd March	150-200 (175)	Weight loss of guggul gum		
11	Otam Singh	Khudo	9th March	300-400 (350)	Thick	Normal	17th March	100-200 (150)	Loose thickness of gum as compared to 2013-14	Same as last year no more changes	
12	Pooja Ram	Khudo	10th March	300-400 (350)	Thick	Normal	21st March	150-200 (175)	Thin	Plants looked like more green as compared to last year	
13	Gopal Singh	Khudo	12th March	300-350 (325)	Thick	Normal	19th March	00-00 (00)**	Thin	Much vegetative growth	
14	Ram Naresh	Khudo	12th March	200-250 (225)	Thick	Normal	24th March	50-100 (75)	Loose thickness of gum as compared to 2012-13	Same as last year no more changes	
15	Pappu	Khudo	16th March	400-500 (450)	Thick	Normal	23rd March	200-250 (225)	Thin		
16	Uma Sanker	Khudo	12th March	400-500 (450)	Thick	Normal	16th March	200-250 (225)	Quality low as compared to 2012-13		
17	Shri Kishan	Khudo	7th March	400-500 (450)	Thick	Normal	13th March	00-00 (00)**	Quality low as compared to 2012-13		
Overall mean				**385.30**	**Overall mean**			**145.59**			

**washed in rain; Figures are parenthesis are mean values

Effects of winter rain on guggul plants health

In comparison to the year 2012-13, the plants appeared healthier with good vegetative growth during 2013-14. Those plants which were not tapped in 2013-14 were also healthier than those tapped during 2012-13 [Table-2]. Primary metabolites convert to secondary metabolites under abiotic stress condition [10]. As there was less or no abiotic stress in 2013-14, this may be the reason for plant that appeared healthier. Primary metabolites are compounds that are directly involved in the growth and development of a plant whereas secondary metabolites are compounds produced in other metabolic pathways that, although important, are not essential to the functioning of the plant [14]. The annual rainfall was showed strong negatively correlated (r=-0.23 and r=-0.50) during both the years. *C wightii* was reported to be available on hilly rocky areas and sandy tracts of coastal areas as well as arid zone of India, which prefers rainfall of 225-500 mm with the temperature ranging between 0-48ºC [15]. Water deficit stress has differential influence on above and underground growth of plants and profound negative effect on shoot growth [16, 12]. During leafless period *C wightii* tends to produce higher gum yield in the months when a combination of climatic factors ensures dry conditions and the atmospheric relative humidity has been low. The association of gum yield with hot dry weather is a commonly reported phenomenon in gum oozing plants. The most likely factor that triggers gum yield during the dry season is water stress [17] but high temperatures, hours of sunshine may also play a role. One possible advantage to higher gum production during the dry season is that because many trees are leafless at this time.

Impacts of climate changes on guggul plant tapping period

Tapping of Guggul in MP is carried out from last week of February to March [7]. In comparison to the year 2012-13, during the year 2013-14, the time of tapping was delayed by one week. The delay was due to low temperature and high humidity during the tapping period. [9] reported that plants have an inbuilt ability to adjust to circadian and seasonal environmental variables. In fact, these variables are often important factors in controlling certain physiological attributes such as length of the vegetative phase, onset of the reproductive cycle, flowering intensity, timing of fruit set and induction of whole plant senescence. At low temperature and high humidity guggul gum formation is low [18]. During the year 2013-14 the guggul plants were under less stress due to winter rain. The maximum temperature was showed strong positive correlation with minimum temperature (r=0.97*), pan evaporation (r=0.98*) and wind speed (r=0.98*) while it was negatively correlated with relative humidity morning (r=-99**), evening (r=-0.92) and rainfall (r=-0.48). [10] reported that the environmental factors *viz.* temperature, humidity, rainfall, light intensity, the supply of water, minerals and CO_2 influence the growth of a plant and secondary metabolite production. The minimum temperature was showed positively high correlation with pan evaporation (r=0.97*) and wind speed (r= 0.99**) and negatively correlated with relative humidity morning (r=-0.97*) as well as evening (r=-0.93) and rainfall (r=-0.28). Morning relative humidity with evening relative humidity (r=0.96*), rainfall (r=0.46) while it was negatively correlated with pan evaporation (r=-0.955*) and wind speed (r=-0.970*) however, evening relative humidity with rainfall (r=0.33) but negatively with pan evaporation (r=-0.85) and wind speed (r=-0.90) during the year of 2012-13 [Table-3]. Due to frequent winter rain during 2013-14 in the Chambal area there was high evaporation and evapo-transpiration, leading to low temperature and high humidity, especially during tapping season. At tapping time, weather conditions *viz.* rainfall, relative humidity, pan evaporation and temperature are the most important variables influencing gum yield from *C wightii*. However, in the year of 2013-14 the maximum temperature was showed positive correlation with minimum temperature (r=0.96*), pan evaporation (r=0.85*) and wind speed (r=0.53) while it was negatively correlated with relative humidity morning (r=-97*), evening (r=-0.98*) and rainfall (r=-0.20) whereas, the minimum temperature positively correlated with pan evaporation (r=0.95*) and wind speed (r=0.73) and negatively correlated with relative humidity morning (r=-0.91), evening (r=-0.99**) and rainfall (r=-0.42). Relative humidity directly influences the water relations of plant and indirectly affects leaf growth and photosynthesis rate. As the relative humidity was higher in 2013-14, the plant may have produced low gum. Morning relative humidity was correlated with evening relative humidity (r=0.95*), rainfall (r=0.15) while it was negatively correlated with pan evaporation (r=-0.77) and wind speed (r=-0.41) however, evening relative humidity with rainfall (r=0.38) but negatively with pan evaporation (r=-0.92) and wind speed (r=-0.65) [Table-4]. Winter rain increased soil moisture and reduced abiotic stress as the weather remained comparatively cool. These changes may have influenced drastic reduction in gum yield. The present findings is in agreement with that of [18] that high temperature at tapping time is conducive to high gum production while low temperature seems to seal off the gum exudation points resulting in low yield. [19] also reported that peak gum production is apparently stimulated by high temperature and low humidity.

Table-3 *Correlation coefficient of gum production with weather parameters during the year 2012-13*

Variables	Gum production	Temp. maxi	Temp. mini	RH morn	RH even	Rain fall	Evaporation	Wind speed
Gum production	1.00							
Temp. Maxi	0.34	1.00						
Temp. mini	0.31	0.97*	1.00					
RH Morn	-0.46	-0.99**	-0.97*	1.00				
RH Even	-0.65	-0.92	-0.93	0.96*	1.00			
Rain fall	-0.23	-0.48	-0.28	0.46	0.33	1.00		
Evaporation	0.17	0.98*	0.97*	-0.95*	-0.85	-0.43	1.00	
Wind speed	0.25	0.98*	0.99**	-0.97*	-0.90	-0.35	0.99**	1.00

Table-4 *Correlation coefficient of gum production with weather parameters during the year 2013-14*

Variables	Gum production	Temp. maxi	Temp. mini	RH morn	RH even	Rain fall	Evaporation	Wind speed
Gum production	1.00							
Temp. Maxi	0.17	1.00						
Temp. mini	-0.06	0.96*	1.00					
RH Morn	-0.35	-0.97*	-0.91	1.00				
RH Even	-0.07	-0.98*	-0.99**	0.95*	1.00			
Rain fall	-0.50	-0.20	-0.42	0.19	0.38	1.00		
Evaporation	-0.30	0.85	0.95*	-0.77	-0.92	-0.64	1.00	
Wind speed	-0.69	0.53	0.73	-0.41	-0.65	-0.78	0.89	1.00

Conflict of Interest: None declared

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