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Ethephon
(2-Chloroethylphosphonic Acid) Application and Gummosis in *Anogeissus pendula* Edgew.

Present study was carried out to standardize the dose of ethephon (2-chloroethylphosphonic acid), a gum inducer hormone and suitable month for its application to optimize gum yield from Anogeissus pendula without deteriorating tree health. Separate A. pendula trees were used to inject with three different doses of ethephon viz., 390 mg/4ml (10%), 780 mg/4 ml (20%) and 1170 mg/4 ml (30%) active ingredients at monthly intervals during a complete year (March, 2010 to February, 2011). Increase in mean gum yield with the increase in ethephon dose was recorded. Maximum mean gum yield was recorded in March, 2010 (57.18g/tree) and minimum in August, 2010 (0.17g/tree). The cumulative gum yield was recorded maximum during summer (1028.90g), followed by winter (965.00g) and rainy season (862.00g). Applications of ethephon had no effect on tree health; however, its use significantly increased sugar content of the wood after one month of the application. Higher dose of ethephon produced higher sugar content in the wood of A. pendula. Thus, the results of present study suggested that higher gum yield can be obtained from higher dose of ethephon during summer season, without affecting the tree health.

***Key words*:** Bundelkhand region, Gum inducer, Gum-gatti, Sugar content.

Ethephon induced gummosis enhances yield of gum in A. pendula without damaging tree health.

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Introduction

Anogeissus pendula Edgew. (kardhai) is a very important tree species of the fragile ecosystems. It belongs to family Combretaceae and occurs naturally in arid and semi-arid areas, particularly in Bundelkhand region of Central India. *A. pendula* offers livelihood option if it's potential is utilized fully. It is an important tree species for afforestation purposes in arid and semi-arid regions of the country. Its timber is very tough and has high mechanical strength, which is being used in making furniture, agricultural implements, etc. Due to higher calorific value, it is generally used as fuel wood. Its leaves are used as fodder and its bark yields a gum called *gatti* or *Indian gum* exudation of which, is rare in nature.

Gum is one of the important non-timber forest produce and viable source of income to forest dwellers, especially tribes of India. In our region, tribal peoples generally tap the plants for gum exudations by blazing, peeling or by making deep cut in the base of the tree trunk (Prasad *et al*., 2016). These methods are wasteful and injurious to the trees which often lead to their death. Moreover, the gum exudation from *A. pendula* is generally negligible in nature. One way to overcome this constraint could be the use of chemical compounds which induces gummosis, such as plant hormones. *E*thephon (2-chloroethylphosphonic acid) is t*he most promising* compound among gum inducers. Ethephon is a synthetic compound of ethylene, phosphate and chloride ions. Enhanced gum yield in ethephon treated plants have been reported by several workers (Miyamoto *et al*., 2010; Harsh *et al*., 2013; Li *et al*., 2014). However, its injudicious use may also lead to the death of the plants (Bhatt and Ram Mohan, 1990).

Several workers have tested the successful use of ethephon in various gum and resin yielding plant species but similar reports on Anogeissus sp. are meager in literature (Bhatt, 1987; Kuruwanshi and Katiyar, 2017). Moreover, researchers have reported increased gum yield due to increased

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concentration of ethephon (Harsh et al., 2013; Bhatt and Ram Mohan, 1990) but some contradictory results have also been reported, which showed less yield with higher concentration and high yield with lower concentration of ethephon (Abib *et al.*, 2013). Therefore, as a part of research activities of ICAR-Network Project on Harvesting, processing and value addition of natural resins and gums, a study was undertaken to standardize the doses of ethephon and season of its application for optimizing gum yield from *A. pendula* without deteriorating tree health.

Material and Methods

The study was conducted at ICAR-Central Agroforestry Research Institute, Jhansi (24^0 11' N and 78^0 17' E), Uttar Pradesh, India. Mean annual rainfall of the region is 960mm, with an average of 52 rainy days per year. Mean maximum temperature ranges from 47.4^0 C (June) to 23.5^0 C (January) and mean minimum temperature from 27.2^0 C (June) to 4.1^0 C (December). May and June are the hottest months. The maximum recorded temperature on a particular day often touches 47–48^0 C in the summer. The main soil types at the experimental fields are red and black. Red soil occurs in upland which is shallow, gravelly and light textured and black soil occurs in comparatively low lying areas which is fine-textured and highly water retentive. Soil pH varies from 5.70 to 6.78 and organic C from 0.38 to 0.67%. The topography of the region is undulating.

The pre-existing plantation of *A. pendula* (>15 years old), raised at experimental farm of the institute was taken into consideration for gum tapping, which consisted of tissue culture raised progenies of five plus trees of *A. pendula*. To study the effect of ethephon (Ethephon 39%; brand name: Tagpon-39), its three different doses viz., 390 mg/4 ml (10%), 780 mg/4 ml (20%) and 1170 mg/4 ml (30%) active ingredients of ethephon, were used which were replicated on four separate trees. The trees having 25-30 cm girth were selected for the purpose. Ethephon was procured from Tropical Agrosystem Ltd., Chennai, India. To make different doses of ethephon, 39% ethephon solution was dissolved in distilled water to get 10, 20 and 30% of solutions. Four ml dose of each concentration was injected in the trees. Moreover, to study the effect of season on gum exudation, present study was carried out throughout the year *i.e.* from March, 2010 to February, 2011 which can be divisible into three different seasons *i.e.* summer (March to June), rainy (July to October) and winter (November to February). At every month, 12 trees of almost similar height and GBH were used to inject ethephon; thus, a total of 144 trees (12×12) were employed in the study. Observations on tree height (inches) and GBH were recorded for each tree.

For application of ethephon, one hole (20 mm diameter, 3 cm deep) was made at 45^0 angle in downward direction on the base of each tree trunk (0.3–0.4 m above collar) with the help of tree borer. One, four ml dose of each concentration of ethephon was injected in the hole during first week of each month and immediately after injection, holes were used to plug with mud ball. A care was taken at the time of ethephon application which aimed to prevent wastage of ethephon due to outfall and ensured that a maximum amount of the applied ethephon should be available to the tree. After 15 days of ethephon application, observation on gum yield (g)/tree was recorded. Throughout the study period, the trees injected with ethephon were monitored for any defoliation and dryness or casualty to assess the tree health.

To study the effect of ethephon application (10, 20 and 30%) on sugar content of wood, a separate study was carried out in the same stand of *A. pendula.* A total of 36 tress (12 trees per each concentration), were selected and wood samples were collected, for the estimation of sugar content before and after one month of ethephon application. Ethephon was injected in the same manner, as mentioned above and sugar content was estimated by using Anthrone method (Yemm and Willis, 1954).

All the data were analyzed statistically using a General Linear Model (GLM) for analysis of variance. Least significant difference ($LSD_{0.05}$) was used to compare treatment differences. ANOVA was performed by using the statistical package SYSTAT version 12 and graph was prepared by using Microsoft Excel.

Results and Discussion

Results on effect of different doses of ethephon on gum exudation from *A. pendula* in different months are presented in Table 1. The results showed that the doses of ethephon as well as month of application had significant influence on mean gum yield. Mean gum yield significantly (P<0.05) increased with increase in the concentrations of ethephon. It was recorded maximum in treatment having 1170 mg (22.42 g), followed by 780 mg (19.46 g) and 390 mg a.i. of ethephon (17.63 g), irrespective of month of application. Higher gum exudation at high concentration of ethephon could be due to the developmental response of plants to dehydration stress induced by ethephon (ethylene) application. As it is well known that whenever ethephon (consisting of ethylene, phosphate and chloride ions) is injected into the plants, it metabolizes and converts in ethylene gas which triggers various developmental responses in plants (Hall and Smith, 1995). Our results corroborate with the results of Bhatt and Ram (1990). They reported increased gum yield with increased ethephon concentration in *Acacia senegal*. In *Anogeissus latifolia*, similar increase in gum yield with the increase in concentration of ethephon was reported by Kuruwanshi and Katiyar (2017). Further, results showed that gum yield varied from tree to tree. As already mentioned that a total of 48 trees per each ethephon concentration (four trees for each concentration at monthly intervals) were injected and out of which 71% of trees responded to treatment with 1170 mg a.i. of ethephon, 58% to treatment with 780 mg a.i. of ethephon and 54% to treatment with 390 mg a.i. of ethephon. More or less similar results have been recorded in *A. senegal* and in *Butea monosperma* in arid and semi-arid regions of India (Harsh *et al*., 2013; Prasad *et al*., 2014).

Significantly higher mean gum yield was recorded in March, 2010 (57.18 g), followed by October, 2010 (53.75 g) while it was recorded least in August, 2010 (0.17 g), irrespective of the concentrations of ethephon. Further, data depicted in Fig. 1 clearly showed that cumulative gum yield was recorded maximum during summer (1028.90 g), followed by winter (965.00 g) and rainy season (862.00 g). This shows that exudation of gum is

Table 1: Effect of different concentrations of ethephon on gum yield (g) from *Anogeissus pendula* during a year.

Month of application	Gum yield (g)/tree at ethephon concentrations			Mean
	10%	20%	30%	
March, 2010	25.25±20.09	67.75±13.72	78.50±22.37	57.18
April, 2010	1.25±2.50	0.00±0.00	10.00±20.00	3.75
May, 2010	18.75±21.75	0.00±0.00	10.00±2.16	9.58
June, 2010	3.00±6.00	27.25±10.05	15.50±1.73	15.25
July, 2010	0.00±0.00	10.00±2.71	10.00±7.62	6.67
August, 2010	0.00±0.00	0.00±0.00	0.50±0.58	0.17
September, 2010	1.75±2.36	24.25±9.12	7.75±7.37	11.25
October, 2010	37.5±10.38	58.50±22.88	65.25±8.81	53.75
November, 2010	29.25±7.85	41.00±1309	12.25±16.54	27.50
December, 2010	10.25±18.55	0.00±0.00	42.00±19.13	17.42
January, 2011	14.50±18.29	1.00±2.00	4.75±6.19	6.75
February, 2011	70.00±27.68	3.75±2.87	12.50±25.00	28.75
Mean	17.63	19.46	22.42	
			$LSD_{0.05}$	
		F-ratio	P value	$LSD_{0.05}$
Month of application		25.270	0.000	2.73
Concentration of ethephon		1.675	0.027	1.54
Month of application × concentration of ethephon		7.382	0.000	5.11

Table 2: Wood sugar content (g/mg wood) in *A. pendula* before and after application of different concentrations of ethephon.

Treatment	Wood sugar content (mg/g wood) at ethephon concentrations			Mean
	10%	20%	30%	
Control (Before application of ethephon) One month after ethephon application Mean	2.792±0.399	2.781±0.421	2.964±0.337	2.846±0.386
	4.597±0.513	4.871±0.816	5.196±0.520	4.888±0.662
	3.695±1.026	3.826±1.242	4.080±1.218	
			$LSD_{0.05}$	
		F-ratio	*P* value	$LSD_{0.05}$
Treatment		273.100	0.000	0.247
Concentration		3.354	0.041	0.303
Treatment x concentration		1.031	0.362	0.428

linked to a climatic conditions. It is well known that plant exudes comparatively higher gum during warm season. Bhatt (1987) reported 21 times higher gum yield in *A. latifolia*, treated with 1600 mg active substance of ethephon, during summer season (April-May) than the yield recorded during winter season (December-January). Low gum yield during rainy season (July to October) could be due to rains, which wash out the gum exuded from the trees. Moreover, it has been reported by several workers that gum exuded during rainy seasons are less viscous as compared to the gum exuded during summer and winter seasons, which could be the reason of lesser gum yield. Tree to tree gum yields varied from 0-122 g during summer, 0-81 g during rainy and 0-93 g during winter seasons. The two-way interaction between concentrations of ethephon and month of application was significant (Table 1). Maximum gum yield was recorded in trees injected with 30% ethephon during March, 2010 and it was significantly different than others.

Observations on tree health during the study period *i.e.* throughout the year revealed that use of ethephon did not show any negative effect on trees in terms of defoliation, wilting or drying. However, its use significantly increased sugar content of wood after one month of application, irrespective of doses of ethephon (Table 2). Sugar content increased with the applied dose of ethephon with its maximum value (4.080 mg/g) in trees injected with 4 ml dose of 1170 mg a.i. (30%), and minimum (3.70 mg/g) in 390 mg a.i. (10%) of ethephon. At each concentration,

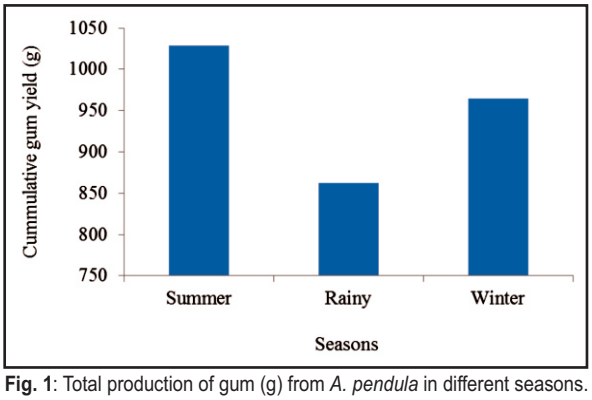

Fig. 1: Total production of gum (g) from *A. pendula* in different seasons.

significantly higher sugar content was recorded after one month application of ethephon. Increase in sugar content of wood after ethephon application has also been reported in Hevea brasiliensis (Dian *et al*., 2016). The hole made at the base of tree trunk heals up in six months and tree is ready for tapping gum through ethephon injection in next season.

Conclusion

The results of present study suggested that application of ethephon @ 1170 mg/4 ml in the month of March and October may enhance gummosis and yield of gum in *A. pendula* trees without any negative impact on tree health, and may provide livelihood options for poor people and/ or tribes inhabiting in and around forest area.

एनोजीसस पेन्डुला एन्ज्यू. में गोंदार्ति और इथीफोन (2-क्लोरोइथीलफॉस्फोनिक एसिड) अनुप्रयोग

राजेन्द्र प्रसाद, वी.डी. त्रिपाठी, अशोक शुक्ला, बी. आलम, ए.के. हान्डा, प्रशान्त सिंह, आर. सिंह और ओ.पी. चतुर्वेदी

सारांश

वृक्ष स्वास्थय की अवनति किए बिना *एनोजीसस पेन्डुला* से गोंद उत्पादन को इष्टतम करने के लिए इसके अनुप्रयोग हेतु उपयुक्त माह और एक गोंद प्रेरक हार्मोन इथीफोन (2-क्लोरोइथीलफॉस्फोनिक एसिड) एक पूर्ण वर्ष (मार्च 2010 से फरवरी, 2011) के दौरान मासिक अंतरालों पर इथीफन की तीन अलग-अलग मात्राओं, यथा 390 mg/4ml (10%), 780 mg/4ml (20%), और 1170 mg/4ml (30%), सक्रिय अवयवों, के साथ अन्तःक्षेपण हेतु पृथक-पृथक *एनोजीसस पेन्डुला* वृक्षों का उपयोग किया गया। इथीफोन की मात्रा में वृद्धि के साथ औसत गोंद उत्पादन में वृद्धि अभिलिखित की गई। अधिकतम औसत गोंद उत्पादन (57.18ग्रा. प्रति वृक्ष) मार्च, 2010 में और अगस्त 2010 में न्यूनतम (0.17 ग्रा. प्रति वृक्ष) अभिलिखित किया गया। संचयी गोंद उत्पादन गरमी के दौरान अधिकतम (1028.90ग्रा.), इसके पश्चात सरदी (965.00ग्रा.) और वर्षाती मौसम (862.00ग्रा.) में अभिलिखित किया गया। इथीफोन के अनुप्रयोग का वृक्ष स्वास्थय पर कोई प्रभाव नहीं पड़ा। तथापि, इसके उपयोग से अनुप्रयोग के एक माह बाद काष्ठ की शर्करा मात्रा में महत्वपूर्ण रूप से वृद्धि हुई। इथीफोन की उच्च मात्रा ने *एनोजीसस पेन्डुला* के काष्ठ में उच्च शर्करा मात्रा का उत्पादन किया। अतः वर्तमान अध्ययन के परिणाम संकेत करते हैं कि वृक्ष स्वास्थय को प्रभावित किए बिना गरम मौसम के दौरान इथीफोन की उच्च मात्रा से उच्च गोंद उत्पादन प्राप्त किया जा सकता है।

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