The Pharma Innovation Journal 2023; 12(7): 1730-1735

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(7): 1730-1735

www.thepharmajournal.com
Received: 01-04-2023
Accepted: 08-05-2023

Nutan Singh
Department of Plant Physiology, Agricultural Biochemistry and Medicinal and Aromatic Plants, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Pratibha Katiyar
Department of Plant Physiology, Agricultural Biochemistry and Medicinal and Aromatic Plants, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Manendra Kumar Ghritlahare
Department of Plant Physiology, Agricultural Biochemistry and Medicinal and Aromatic Plants, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Sunita Singh
Department of Genetics and Plant Breeding, SGCARS Jagdalpur, Raipur, Chhattisgarh, India

Corresponding Author:
Nutan Singh
Department of Plant Physiology, Agricultural Biochemistry and Medicinal and Aromatic Plants, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Comparative study of biopolymers exudation and tapping techniques of major Gum/Resin trees of Balrampur, North Chhattisgarh Region

Nutan Singh, Pratibha Katiyar, Manendra Kumar Ghritlahare and Sunita Singh

Abstract
Biopolymer produced from natural resources used in various industrial ranging from food, pharmaceutical and medicines etc. are in increasing demand globally. Therefore the investigation on "Comparative study of biopolymers exudation and tapping techniques of major Gum/Resin trees of Balrampur, (North Chhattisgarh Region)" was carried out at village Chando district Balrampur (Chhattisgarh) and the laboratory work was done in the department of Plant Physiology, Agricultural Biochemistry and Medicinal and Aromatic plants, Collage of Agriculture, IGKV, Raipur (C.G.) during the year 2018-19 and 2019-20 to compare various methods of tapping of biopolymers and evaluate the qualitative and quantitative traits of gum in two experimental trees *i.e.*, Dhawara (*Anogeissus latifolia*) and Salai (*Boswellia serrata* Roxb.) in a different season of tapping to develop the techniques for sustainable production and quality. The analysis was done using RBD replicated thrice. The four mechanical T_1 Single cut (Traditional), T_2 (Semi arc), T_3 (single V shape), and T_4 (double V shape) and in use of 12 gum enhancer *i.e.* T_1 Control (@4 ml distilled water), T_2 (@3.9% Ethephon), T_3 @(4.8% Ethephon), T_4 (@5.5% Ethephon), T_5 (@10% H_2SO_4), T_6, (3.9% Ethephon + 10% H_2SO_4), T_7 (@4.8% Ethephon +@ 10% H_2SO_4), T_8 (@5.5% Ethephon + @10% H_2SO_4), T_9 (NAA @250 ppm), T_{10} (Maleic Hydrazide@5%), T_{11}(L- methionine @250 ppm), T_{12} (Jasmonic Acid JA @1%). The main aim of the study was to develop the technology for tapping the tree throughout the year. As compared to mechanical method as well as traditional methods the use of gum enhancer was found to be significantly superior and safe. In Dhawda (*Anogeissus latifolia*) the use of Ethephon and H_2SO_4 (@10%) was found to be effective in summer while in winter tapping its combined effect (ethephone + H_2SO_4 @10%) was found to be best. However, in Salai (*Boswellia serrata* Roxb.) combined effect of ethephone + H_2SO_4 @10% was found to significantly effective in creating artificial stress to induce the mechanism of gummosis in three experimental trees. The physiochemical properties of gum tapped by mechanical, traditional and gum enhancer indicated that there were non-significant differences in their properties of gum in moisture content, ash content, protein and nitrogen content, viscosity, solubility, and pH value.

Keywords: Ethephon, biopolymers, exudation, techniques, Gum/Resin

Introduction
Forest trees have a pivotal role in social life and income of Tribal's and source of livelihood. It is an important source of timber as well as now wood forest products. Now a days gradual deforestation is a major reason of declining the production of gum resin and other non-wood forest product (NWFPs). Product likes essential oil, dyes, honey, tannin and bamboo cane products etc. In plants, the natural gums are formed through a process called gummosis in which internal plant tissues, mostly cellulose, are disintegrated and decomposed. They ooze out from the plant stems either naturally or when plant stems are wounded by external force. They are insoluble in alcohol and ether but soluble in water. Being important commodity humans have not only employed gums for ceremonial, esthetic and therapeutic uses but also in arts and industry, as a result they have been traded as the most sought material between the different cultures around the world from the earliest times. Commercially, they are sold in the form of dried exudations. Ethephon is safe, inexpensive and non-toxic. It is used for enhancing rubber yield in rubber tree, ripening of fruits (mango, bananas and citrus), induction of abscission, flowering, root initiation, seed germination and breaking of dormancy. About 120 gum and resin yielding plant species are known to grow in India, and they inhabit different eco-climatic zones. The forests in central India support a rich diversity of tree species, many of them provide valuable gums.

However, these tree species are less studied, especially with respect to their indigenous uses of gums, and also the existing information is scattered. Being an important commodity for livelihood generation, there are unsustainable harvesting issues, which impact the population of these species. At present, understanding the complex relationships between harvest and conservation of these species is a need of hour. Therefore, innovation in technology is needed to improve the quantity and quality of production for sustainable tapping. Therefore the gum enhancer were used for tapping purpose and evaluate its efficacy on Dhawda (*Anogeissus latifolia*) and Salai (*Boswellia serrata* Roxb.) and compared it with a mechanical method of tapping as well as traditional tapping. The may be objective of the study was to develop of an effective and safe method for potential production of gum /resin. Therefore, these tree species were selected for study purpose Balrampur Chhattisgarh for experimental purpose. The selection of experimental trees were made on the basis of tree girth all type of tapping were made via using traditional, mechanical and gum enhancer at 1DBH (137cm above the ground surface).

Materials and Methods

Dhawda (*Anogeissus latifolia*) and Salai (*Boswellia serrata* Roxb.) trees observe one diameter was selected for tapping purpose and treated with traditional method T_1 (Single cut with axe), mechanical method T_2 Semi arc (10 cm width x 5 cm length x 4 cm deep size), T_3 Single V shape and T_4 Double V shape cut. Twelve gum enhancer *i.e.* T_1 Control (@4 ml distilled water), T_2 (@3.9% Ethephon), T_3 @(4.8% Ethephon), T_4(@5.5% Ethephon), T_5 (@10% H_2SO_4), T_6 (3.9% Ethephon + 10% H_2SO_4), T_7 (@4.8% Ethephon +@ 10% H_2SO_4), T_8 (@5.5% Ethephon + @10% H_2SO_4), T_9 (NAA @250 ppm), T_{10} (Maleic Hydrazide@5%), T_{11} (L-methionine @250 ppm), T_{12} (Jasmonic Acid JA @1%) were used and injected 4 ml by syringe and covered with mud at 1 DBH (137cm, distance at breast height) in winter and summer session in two consequent year of experimental 2018-19 and 2019-20. The time of application was selected at morning and rate of gum exudation was recorded monthly. For winter tapping the tapping method were applied in October and for summer tapping, tapping method were applied in February. The rate of exudation was calculated on the basis of dry weight of gum/exudates obtained after application of gum tapping treatments. RBD in three replication were used for analysis of data and pooled analysis two experimental years were used for depicting the data.

The mechanism of gummosis plays pivotal role in biopolymer exudation and the depth of bark forms due to environmental stress or internal process of ethylene formation due to stress in controlled genetically and the mechanism is trigger by any cause while artificially or naturally induces the signal of ethylene production inside the sap wood. Hence, ethylene is the major function responsible for the induction of gummosis. Ethephon (2-chloroethyl-phosphonic acid) is ethylene releasing compound and it is eco-friendly and bio-safe and used in agriculture and forest crop for various purposes. Abiotic (drought, salinity, high temp., low RH %, abrasion, wound) and biotic stress (insect, pest, infestation, wound etc.) induce ethylene production.

Results and Discussions

The comparative study on tapping of all the experimental trees *i.e.,* Dhawda (*Anogeissus latifolia*) and Salai (*Boswellia serrata* Roxb.) were done in whole the year in two consecutive year 2018-19 and 2019-20 using mechanical and gum enhancer and observed that the season of tapping play significant role on exudation on high temperature and low RH having significant impact on quantity of gum in all the experimental tress. Hence, in the summer season (Feb to June) a higher quantity of gum was obtained as compared to winter season. The height at which the tapping were done have a significant role in potential production of gum. Therefore, more than one meter above the ground surface 1DBH (137cm distance at breast height) was found superior as compared to half meter and 1.5 m height. The diameter of tree trunk should be not less than 1m in Dhawda (*Anogeissus latifolia*) and 90cm in Salai (*Boswellia serrata* Roxb.) for tapping purpose. The sap wood were used to inject the gum enhancer and the depth of sap wood varied depends on age of the tree. The appropriate depth for incision were 2.5-3.0cm in Dhawda (*Anogeissus latifolia*) and 2cm in Salai (*Boswellia serrata* Roxb.) for more exudation. The process of gummosis and exudation started within week in mechanical method whereas in gum enhancer methods of tapping it take 2-3 days in all experimental trees when treatment were applied on 1st week of march 2018. The quantity of gum produced by two experimental trees was significantly higher in Salai (*Boswellia serrata* Roxb.) and minimum gum was obtained in Dhawda (*Anogeissus latifolia*) in mechanical method of tapping. As for as method concern for production point of view, (T_4) double V shape was found best over other method of mechanical tapping in Dhawda (*Anogeissus latifolia*) and Salai (*Boswellia serrata* Roxb.). In gum enhancer were played significant role in potential production of gum in both the experimental trees. Impact of seasonal variation on gum production indicated that the average production were more in summer compared to winter season in all the experimental trees. In Dhawda (*Anogeissus latifolia*) use of ethephone (3.9-4.8%), and H_2SO_4 (10%) was effective in summer while in winter season combined effect of Ethephon@ 3.9% + H_2SO_4 (10%) was found best to induce the process of gummosis required for gum production. While in Salai (*Boswellia serrata* Roxb.) combined effect of Ethephon + H_2SO_4 was significantly effective in summer as well as in winter tapping. The flow rate of biopolymers was significantly higher in gum enhancer as well as mechanical method within month (Apr & May) in Dhawda (*Anogeissus latifolia*) both the experimental years 2018-19 and 2019-20. Whereas, in Salai (*Boswellia serrata* Roxb.) the rate of gum exudation in gum enhancer methods was significantly higher within month (Sep & May) and mechanical method also observed significantly higher in May month. In Dhawda (*Anogeissus latifolia*) the maximum rate of gum exudation was obtained in between month of April and May in both the experimental years. (101.34 g, 74.21 g and 60.40 g, 83.84 g, respectively), followed by June and March. However, in Salai (*Boswellia serrata* Roxb.) observed in the month of May and September.

The comparative studies of using various gum enhancers in all two experimental trees indicated that in Dhawda (*Anogeissus latifolia*) treatment T_3@4.8% having maximum impact on highest exudation of gum followed by T_2 @ 3.9% Ethephon and T6 @ 3.95 ethephon+H_2SO_4 @ 10%. However, in Salai (*Boswellia serrata* Roxb.) it was observed that the significantly higher exudation was obtained in trees treated with T_8 (@5.5% Ethephon + 10% H2SO4), T_2 (@3.9% Ethephon) followed by T_3 (@4.8% Ethephon). The minimum exudation was observed in T10 (@Maleic Hydrazide 5%)

However, the gum exudation in control T1 (distilled water) was 7.81g and 4.38g in the year 2018-19 and 2019-20 respectively. Ethephon was found to be most effective and when it was applied in combination with H2SO4 have shown more efficacy on production of gum in Salai (*Boswellia serrate* Roxb). It might enhanced the internal stress at cellular level at sap wood and might be enhanced internal ethylene level probably responsible to induce gummosis and increased gum exudation.

Gum tapping through mechanical methods

In mechanical method of gum tapping, wounds are made by axe, sword or some homemade instruments which forms an undefined wound of varied depth due to uncontrolled pressure applied on the stem of the plants and this sometimes lead to irreversible damage and death to the plants (Anonymous, 1997). Therefore in the present experiment standard tapping tool *i.e.* T_1 Single cut (Traditional), T_2 Semi arc, T_3 Single V shape, and T_4 Double V shape were used to form definite size of wound by exerting controlled pressure. The study was done in two consecutive years 2018- 19 and 2019-20 started from March up to December. The blaze on tree trunk healed after few weeks.

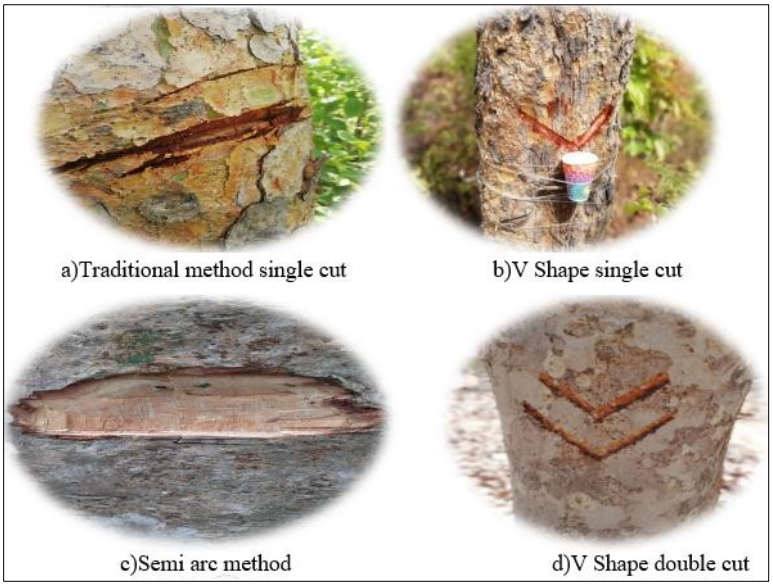

Fig 1: Gum exudation in both experimental trees with different mechanical treatment at, Vill-Chando Dist. Balrampur (C.G.)

Fig 2: Gum exudation in both experimental trees with different gum enhancer treatments at, Vill- Chando Dist. Balrampur

Table 1: Effect of mechanical methods on tapping and rate of gum exudation (g) in Dhawda *(Anogeissus latifolia)* during year 2018-19 and 2019-20 (Elevation-427 MSL)

Treatment	(2018-19)									(2019-20)								
	Mar	Apr	May	June	Sep	Oct	Nov	Dec	Total	Mar	Apr	May	June	Sep	Oct	Nov	Dec	Total
Temp.(°C)	32.5	35.5	37.9	33.9	29.6	30.7	28.2	22.3		30	36.9	39.9	37	29.1	27.7	27.9	22.8	
RH (%)	68	60	63	74	91	83	88	89		76	55	51	71	93	95	91	94	
T_1	01.2	0.4	1.5	0.89	0.64	0.43	0.67	0.35	6.08	0.88	0.33	0.84	0.56	0.34	0.35	0.57	0.45	4.32
T_2	0.85	1.0	1.7	0.95	0.55	0.39	0.61	0.48	6.53	0.39	1.04	0.9	0.62	0.38	0.42	0.61	0.88	5.24
T_3	1.02	0.7	1.4	0.88	0.72	0.73	0.63	0.64	6.72	0.45	0.76	0.88	0.59	0.32	0.38	0.49	0.61	4.48
T_4	0.66	1.3	1.8	0.90	0.34	0.51	0.60	0.70	6.81	0.5	0.88	0.92	0.63	0.4	0.26	0.63	0.82	5.04
Total	3.73	3.4	6.4	3.62	2.25	2.06	2.51	2.17	26.14	2.22	3.01	3.54	2.4	1.44	1.41	2.3	2.76	19.08

T_1 Single cut (Traditional), T_2 Semi arc, T_3 Single V shape, T_4 Double V shape.

Table 2: Effect of mechanical methods on tapping and rate of gum exudation (g) in Salai *Boswellia serrata* Roxb during year 2018-19 and 2019-20 (Elevation- 427 m)

Treatment	(2018-19)									(2019-20)								
	Mar	Apr	May	June	Sep	Oct	Nov	Dec	Total	Mar	Apr	May	June	Sep	Oct	Nov	Dec	Total
Temp.(°C)	32.5	35.5	37.9	33.9	29.6	30.7	28.2	22.3		30	36.9	39.9	37	29.1	27.7	27.9	22.8	
RH (%)	68	60	63	74	91	83	88	89		76	55	51	71	93	95	91	94	
T_1	1.55	0.29	4.10	0.89	3.24	0.98	1.05	0.65	12.75	2.02	1.72	0.82	1.12	0.81	0.92	2.11	0.70	10.22
T_2	0.67	0.87	1.28	1.36	2.21	2.46	0.17	1.27	10.29	1.35	0.97	0.96	1.08	1.22	0.54	1.03	0.62	7.77
T_3	2.76	1.90	1.13	1.06	1.45	3.06	4.25	0.78	16.39	1.30	1.29	0.84	1.17	0.76	1.22	0.73	1.06	8.37
T_4	2.40	1.36	2.11	0.55	3.98	4.20	0.86	3.26	18.72	1.60	0.32	0.66	1.20	1.40	2.14	1.21	0.92	9.45
Total	7.38	4.42	8.62	3.86	10.88	10.7	6.33	5.96	58.15	6.27	4.30	3.28	4.57	4.19	4.82	5.08	3.30	35.81

T_1 Single cut (Traditional), T_2 Semi arc, T_3 Single V shape, T_4 Double V shape

Table 3: Effect of gum enhancer methods on tapping and rate of gum exudation (g) in Dhawda *(Anogeissus latifolia)* during year 2018-19 and 2019-20 (Elevation-427 MSL)

Treatment	(2018-19)									(2019-20)								
	Mar	Apr	May	June	Sep	Oct	Nov	Dec	Total	Mar	Apr	May	June	Sep	Oct	Nov	Dec	Total
Temp.(°C)	32.5	35.5	37.9	33.9	29.6	30.7	28.2	22.3		30	36.9	39.9	37	29.1	27.7	27.9	22.8	
RH (%)	68	60	63	74	91	83	88	89		76	55	51	71	93	95	91	94	
T_1	00.78	00.81	00.72	00.53	0.41	0.33	0.45	0.50	04.53	0.33	0.23	0.62	0.50	0.76	0.42	0.77	0.45	04.08
T_2	7.32	13.44	13.87	10.09	6.31	3.70	6.04	4.77	65.54	5.55	10.57	15.27	8.66	6.85	8.54	6.13	8.20	69.77
T_3	6.34	20.58	11.78	06.34	5.26	3.00	7.05	6.09	66.43	7.14	12.43	13.37	6.69	4.18	12.88	10.00	8.00	74.69
T_4	7.83	10.29	08.17	05.03	4.85	3.15	3.82	3.66	46.81	4.28	7.72	10.26	3.84	6.16	6.34	6.23	8.23	53.07
T_5	5.40	24.31	12.27	07.51	5.19	4.43	5.67	5.71	70.49	4.87	10.62	15.97	9.12	5.04	6.96	6.63	6.18	65.39
T_6	6.87	08.66	07.19	08.89	5.53	4.12	7.22	6.57	55.05	7.46	5.09	8.10	9.48	6.47	8.23	9.02	10.13	63.98
T_7	4.96	11.68	08.48	10.58	5.06	4.08	6.72	5.99	57.55	5.65	7.98	8.14	6.32	4.66	8.05	9.41	8.00	58.22
T_8	4.32	10.08	10.22	4.57	3.38	4.85	5.05	4.95	47.41	5.08	5.01	9.11	6.09	4.77	7.20	6.45	6.81	50.53
T_9	0.87	0.43	0.50	0.45	1.99	0.51	0.47	0.45	5.66	0.35	0.26	1.86	2.09	0.61	0.41	0.58	0.68	6.83
T_{10}	0.50	0.30	0.26	0.35	0.41	0.24	0.29	0.35	2.70	0.20	0.17	0.30	0.30	0.54	0.35	0.59	0.31	2.76
T_{11}	0.76	0.42	0.39	0.34	0.49	0.22	0.44	0.34	3.41	0.25	0.19	0.45	0.38	0.42	0.21	0.46	0.13	2.49
T_{12}	0.80	0.34	0.37	0.30	0.31	0.40	0.36	0.3	3.19	0.39	0.13	0.39	0.42	0.48	0.37	0.47	0.54	3.19
Total	46.75	101.34	74.21	54.98	39.2	29.01	43.57	39.7	428.77	41.56	60.40	83.84	53.90	40.94	59.95	56.73	57.68	454.99

T_1 Control (@4 ml distilled water), T_2 (@3.9% Ethephon), T_3 @(4.8% Ethephon), T_4 (@5.5% Ethephon), T_5 (@10% H_2SO_4), T_6, (3.9% Ethephon + 10% H_2SO_4), T_7 (@4.8% Ethephon +@ 10% H_2SO_4), T_8 (@5.5% Ethephon + @10% H_2SO_4), T_9 (NAA @250 ppm), T_{10} (Maleic Hydrazide@5%), T_{11}(L- methionine @250 ppm), T_{12} (Jasmonic Acid JA @1%).

Table 4: Effect of gum enhancer on tapping and rate of gum exudation (g) in Salai (*Boswellia serrata* Roxb) during year 2018-19 and 2019-20 (Elevation-427 MSL)

Treatment	(2018-19)									(2019-20)								
	Mar	Apr	May	June	Sep	Oct	Nov	Dec	Total	Mar	Apr	May	June	Sep	Oct	Nov	Dec	Total
Temp.(°C)	32.5	35.5	37.9	33.9	29.6	30.7	28.2	22.3		30	36.9	39.9	37	29.1	27.7	27.9	22.8	
RH (%)	68	60	63	74	91	83	88	89		76	55	51	71	93	95	91	94	
T_1	0.99	1.24	0.72	0.49	1.57	0.82	1.15	0.83	7.81	0.33	0.46	0.48	0.50	0.76	0.50	0.57	0.77	4.38
T_2	8.39	12.82	10.19	12.71	15.84	11.66	10.74	10.86	93.21	7.62	14.67	20.41	10.41	13.47	12.22	11.22	8.48	98.50
T_3	7.51	13.40	13.80	10.71	16.42	13.80	12.39	12.51	100.55	11.01	11.69	15.99	8.70	9.12	14.89	9.91	13.74	95.06
T_4	9.24	12.20	10.37	13.15	17.16	7.23	7.18	10.45	86.96	5.35	8.84	14.00	8.79	9.11	9.55	7.37	8.85	71.87
T_5	6.72	11.51	7.61	12.35	8.39	7.45	6.98	14.06	75.09	5.27	7.86	12.11	9.77	6.25	8.53	12.13	5.75	67.68
T_6	11.96	7.14	13.30	10.03	15.60	18.37	9.92	13.47	99.78	9.43	10.67	11.68	7.84	6.13	14.34	10.56	11.18	81.82
T_7	14.20	10.06	16.00	14.55	12.59	7.15	9.30	11.08	94.93	9.32	14.19	11.32	10.87	10.20	12.00	10.81	8.34	87.04
T_8	10.41	9.55	12.18	12.77	16.51	13.43	12.75	14.07	101.68	9.21	9.47	14.11	10.15	12.89	14.59	8.40	11.80	90.62
T_9	0.60	0.54	0.52	0.45	1.16	1.67	0.58	0.69	6.21	0.89	0.34	2.36	2.09	0.71	0.41	0.91	1.02	8.72
T_{10}	0.42	0.30	0.39	0.35	0.75	1.39	0.30	0.67	4.56	0.27	0.22	0.47	0.30	0.71	0.69	0.59	0.64	3.88

T_{11}	0.33	0.39	0.39	0.34	1.49	1.04	0.57	0.48	5.04	0.25	0.26	0.58	0.38	0.92	0.21	0.46	1.00	4.06
T_{12}	0.63	0.34	0.37	0.30	2.65	0.95	0.39	0.70	6.34	0.59	0.12	0.79	0.42	1.14	1.37	0.80	1.28	6.51
Total	71.41	79.49	85.84	88.21	110.12	84.97	72.26	89.86	682.16	59.54	78.80	104.30	70.22	71.40	89.30	73.72	72.85	620.14

T_1 Control (4 ml distilled water), T_2 (3.9% Ethephon), T_3 (4.8% Ethephon), T_4 (5.5% Ethephon), T_5 (10% H_2SO_4), T_6, (3.9% Ethephon + 10% H_2SO_4), T_7 (4.8% Ethephon + 10% H_2SO_4), T_8 (5.5% Ethephon + 10% H_2SO_4), T_9 (NAA 250 ppm), T_{10} (Maleic Hydrazide 5%), T_{11}(L-methionine 250 ppm), T_{12} (Jasmonic Acid JA 1%).

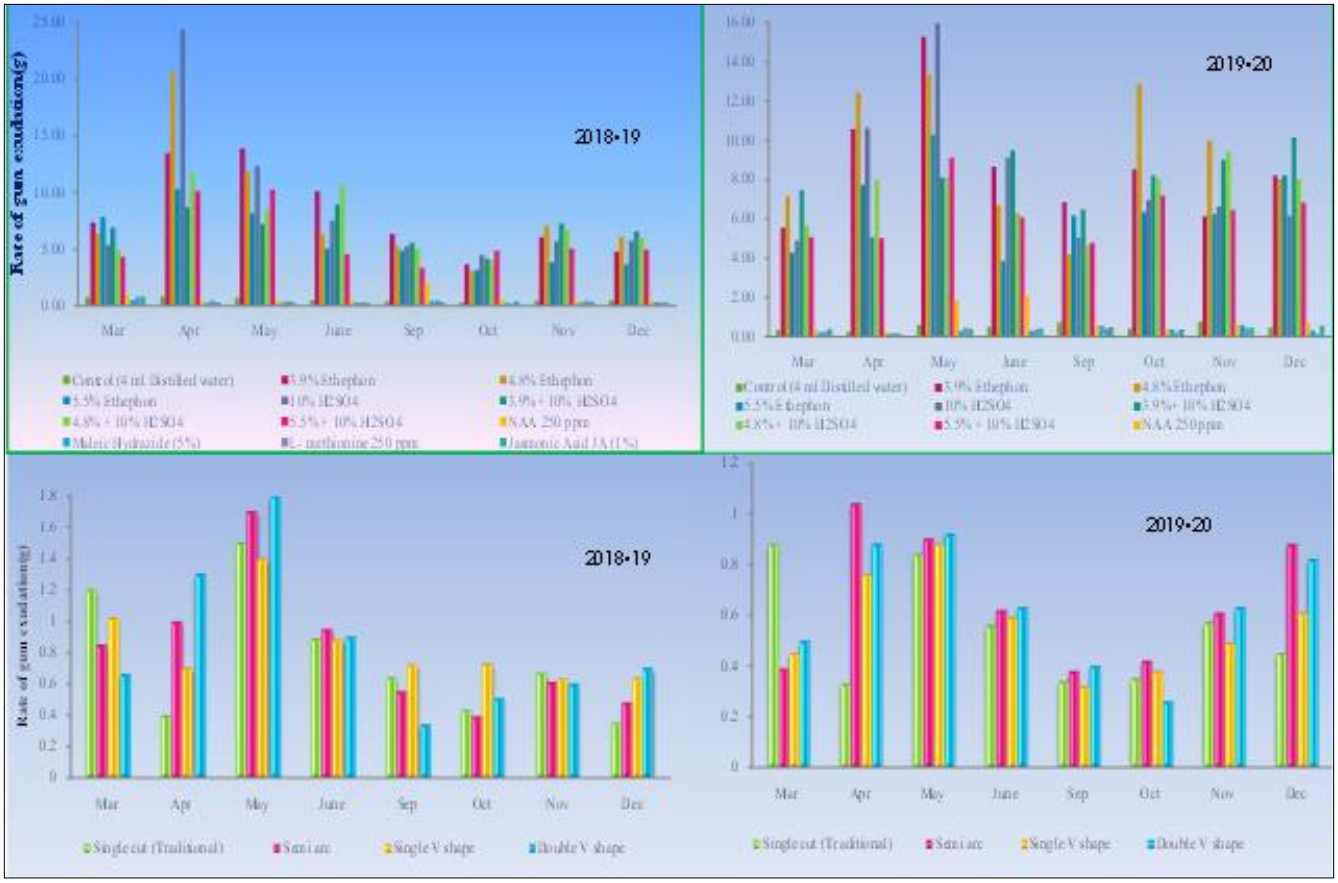

Fig 3: Effect of gum enhancer and mechanical method on tapping and rate of gum exudation (g) in Dhawda (*Anogeissus Latifolia*) during 2018-19 to 2019-20

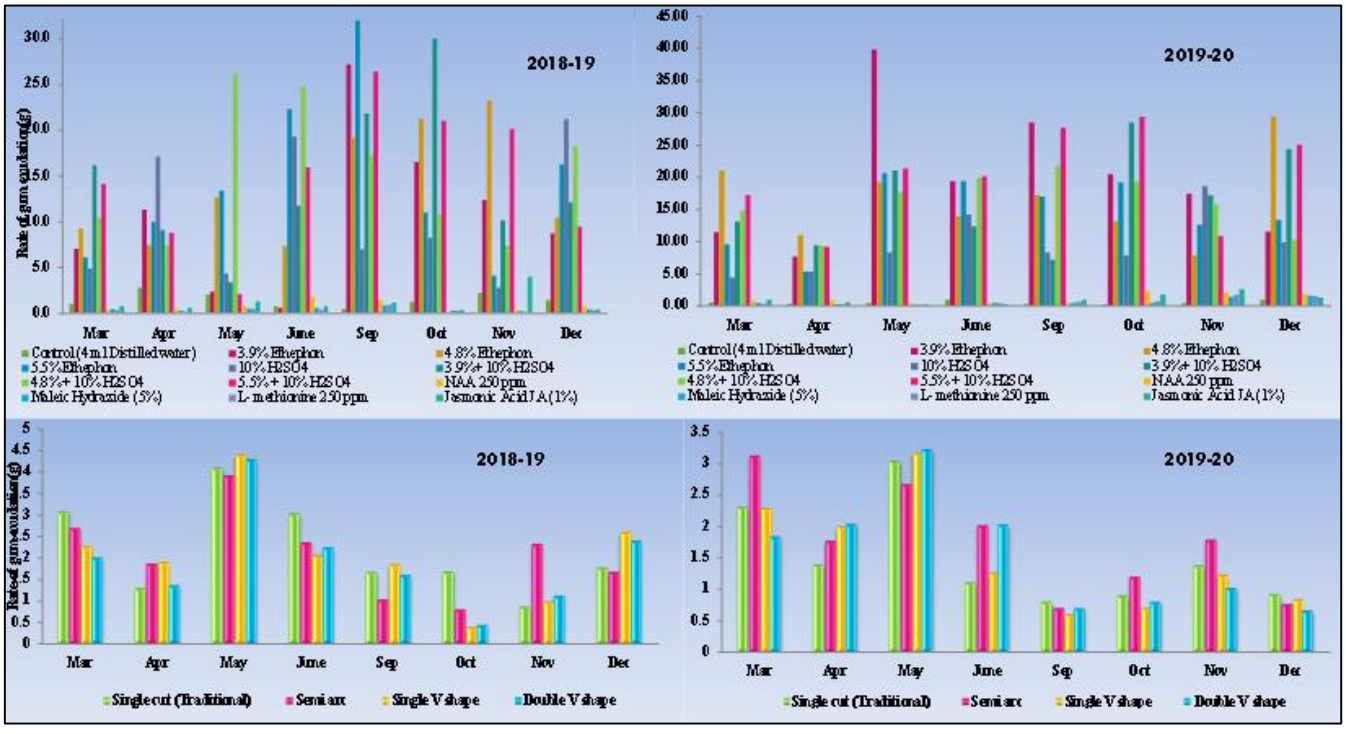

Fig 4: Effect of gum enhancer and mechanical method on tapping and rate of gum exudation (g) in Salai (*Boswellia serrata* Roxb.) 2018-19

Conclusion

Generally gum /resin produced by tree due to environmental adversity, possibly as a protective mechanism, either after mechanical damage to the bark or after a bacterial, fungal or insect attack upon it by the process of gummosis. Hence, the efforts were made to develop mechanical incision via different types of cut on sap wood and various plant growth substance used as gum enhancer to develop artificial stress inside the sap wood to produce ethylene via using under concentration of Ethephon and L- methionine, (as precursor of ethylene biosynthesis), Jasmonic acid, (as an defense role in plant). The main aim of the study was to develop the technology for tapping the tree throughout the year. As compared to mechanical method as well as traditional methods, the use of gum enhancer found to be significantly superior and safe. In Dhawda (*Anogeissus latifolia*) the use of Ethephon and H_2SO_4 (@10%) were effective in summer while in winter tapping its combined effect (ethephone + H_2SO_4 @10%) was found to be best. However, in Salai (*Boswellia serrata* Roxb.) combined effect of ethephone + H_2SO_4 @10% was found to significantly effective in creating artificial stress to induce the mechanism of gummosis in three experimental trees. The appropriate diameter of tree for tapping was >100cm in Dhawda (*Anogeissus latifolia*) and >90cm in Salai (*Boswellia serrata* Roxb.) for potential tapping. The distance where the gum enhancer injected was 1DBH (distance at breast height 1.37cm) and the direction of the application of gum enhancer was found to be more effective in east to south. The depth of the incision 2.5-3.0 cm in Dhawda (*Anogeissus latifolia*) and 2 cm in Salai (*Boswellia serrata* Roxb.)

Acknowledgements

The authors are thankful to ICAR and also acknowledge the financial support Network project on Harvesting Processing and Value addition of Natural Resin and gums during the course of investigation.

References

1. Abeles FB. Ethylene in Plant Biology. Academic Press, New York. 1973, 134.
2. Adam IM, Kama E, Fadl M. Effect of tapping tools and date of tapping on Acacia, 2011.
3. Bada SO, Unanaonwi OE. Effect of Tree Height and Girth on Gum Yield of Acacia Senegal in Savannah Woodland of Nigeria. Journal of Tropical Forestry and Environment. 2013;3(01):40-44.
4. Bhatt JR. Gum tapping in *Anogeissus latifolia* (Combretaceae) using Ethephon. Current Science. 1987;56(18):71.
5. Chae HS, Kieber JJ. Trends Plant Science. 1999;10:291.
6. Chowdhury AR. Characterization techniques of natural resins and gums. In: N. Prasad, N. Thombare, R. Singh, p. Sakare and K.K. Sharma (Eds.), Training Manual on ICAR-NAHEP-CAAST Short Training on Natural Resins and Gums: Production, processing value addition and marketing, ICAR-IINRG, Ranchi; c2020. p. t39 -146.
7. Fadi KEM, Gebauer J. Effect of time and intensity of tapping on the gum yield of *Acacia seyalvar seyal* in South Kordofan, Sudan. Journal of Forests, Trees and livelihood. 2006;16(3):219-225.
8. Fahn A. Secretory Tissue in Plants. Academic Press, London; c1979.
9. Giri SK, Prasad N, Pandey SK, Prasad M, Baboo B. Natural Resins and Gums of Commercial Importance at a Glance. Indian institute of Natural Resins and Gums, Ranchi, Jharkhand; c2008. p. 38.
10. Kamal EM, Adam IM. Effect of tapping tools and date of tapping on *Acacia polyacantha* gum yield in south Kordofan State, Sudan. Journal of Forestry Research. 2011;22(1):117-122.
11. Kamal EM, Ballal EM, Adam IM. Effect of grass density and date of tapping on *Acacia senegal* gum yield in south Kordofan State, Sudan. Journal of forestry Research. 2013;24(1):109-172.
12. Kuruwanshi VB, Katiyar P. Establishment of sustainable gum tapping techniques in Dhawda (*Anogeissus latifolia*) using Ethephon, Trends in Biosciences. 2017;10:1376-1380.
13. Kuruwanshi VB, Katiyar P, Khan S. Gum tapping technique and anatomical study of ethylene induced gum duct formation in Dhawda (*Anogeissus latifolia*). Journal of Pharmacognosy and Phytochemistry, SPl; c2018. p. 24-28.
14. Moola Ram H, Khan A, Naveen S. Tree Gum Tapping Technique of CAZRI Proved to be a Boon of Livelihood for Gum Arabic Tappers of Western Rajasthan in India. Central Arid Zone Research Institute, Jodhpur-34-2003, Rajasthan, India; c2003.
15. Nair MNB, Shivanna KR, Mohan HYR. Ethephon enhances Karaya gum yield and wound healing response: Food Hydrocolloids. 1995;19(4):687-701. ISSN: 0268-005X.
16. Nair B. sustainable utilization of gum and resin by improve tapping technique in some species. Harvesting of non-wood forest products. Menemen-izmir, Turky, 2000 October 2-8.
17. Odo PE. Tapping Gum Arabic plant: Practical Aspect. National Agricultural Extension and Research liaison service (NAERLS) Training Manual on gum Arabic production. *Polyacantha* gum yield in South Kordofan State, Sudan. J Fores Res. 1994;22:117–122.
18. Simon S, Petrasek J. Why plants need more than one type of auxin. Plant Science. 2011;180(3):454-460.
19. Sinha SK, Pathak JG, Mehta AA, Behera LK. Tapping methods in Salai Guggal (*Boswellia serrata* Roxb.) for sustainable-yield of oleo-gum resin: A case study International Journal of Forestry Usufructs Management. 2016;17(2):I3-18.
20. Sinha SK, Pathak IG, Mehta AA, Behera LK'. Improved tapping methods for extraction of oleo-gum resin Salai Guggal (*Boswellia serrata* Roxb.): A medicinal tree for pharmaceutical industries. In M. Kumari, M. Kumar and S.B. Shah (Eds.) Proceeding cum Abstract Book of National Webinar on Cultivation of medicinal and Aromatic Plants (MAPs): An innovative effort towards sustain development, Nladar-r Bharti Agriculture College Agn'anpur, Saharsa, Bihar. 2020, p.12 13.