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Influence of different Treatment and Patch Geometry on Recovery of Bark in North Eastern *Terminalia arjuna* Linn. f

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ABSTRACT: The current research aimed to investigate the impact of various treatments and patch geometries on bark recovery in *Terminalia arjuna.* The study was conducted in an openly situated plantation of *Terminalia arjuna* standing trees within the Forest Product and Utilisation Department at the College of Horticulture and Forestry in Pasighat, Arunachal Pradesh. Bark extraction was performed on equal-sized trees using two different patch sizes, and various treatments were applied to promote faster bark regeneration. After three months, the healing properties of the bark were assessed as a percentage of recovered bark. The findings of the study revealed that among the different treatments, Bordeaux paste resulted in the highest bark regeneration (39.02%), followed by Bordeaux paste with plastic (36.66%) and Neem Seed Kernel Extract paste (33.39%). These treatments exhibited significantly higher bark recovery compared to the other treatments. Conversely, the control group showed the least bark regeneration (20.61%). Regarding patch geometry, there was minimal variation observed, with narrow strips (P_2) demonstrating slightly higher bark recovery (39.02%) compared to broader strips (36.12%). The research provides valuable insights into suitable treatments and harvesting techniques for sustainable bark extraction in *Terminalia arjuna* in the North-Eastern region.

Keywords: Narrow strips, Neem Seed Kernel Extract (NSKE), Patch geometry, Bark recovery.

INTRODUCTION

Terminalia arjuna, commonly known as arjuna, is a member of the Combretaceae family. Its bark decoction has been utilized in the Indian subcontinent for centuries to treat anginal pain, hypertension, congestive heart failure, and dyslipidemia, based on the observations of ancient physicians (Ahmed *et al.*, 2020). This evergreen tree grows to a height of 6–15 meters and exhibits a buttressed trunk, spreading crown, and drooping branches. The bark is thin, smooth, shining, and greenish-grey, with regular peeling. The leaves are sub-opposite, oblong, or elliptic-oblong, measuring 5–14 × 2-4.5 cm, while the flowers have a greenish-white or creamy hue and a sweet scent. The fruit is fibrous, woody, and glabrous, with a length of 2.3–3.5 cm, featuring five hard wings with numerous curved veins. The tree typically flowers from April to July in Indian conditions. Bark serves as the outermost protective layer surrounding the wood of trunks, branches, and roots of trees. It varies in thickness, color, and appearance among different species and covers the vascular cambium of the stem. However, the current bark harvesting practices are unsustainable, with many harvesters resorting to girdling, removing bark from entire trees, or even cutting down entire trees (Pandey and Mandal 2012). Sustainable harvesting principles dictate that biological resources should be harvested within the limits of their self-renewal capacity while avoiding any environmental degradation (Hamilton, 2005). Sustainable bark harvesting methods largely depend on the response of the target species to bark stripping or blaze-making. Blaze and strip harvesting are viable options that allow bark recovery through sheet or edge development, ensuring a sustainable supply of bark (Hanumantha, 2020). The bark of *Terminalia arjuna* holds commercial value for medicinal and dye purposes, but the current unsustainable practices pose a concern. Unfortunately, there is limited information available on sustainable bark harvesting for this species. Hence, the present investigation assumes a crucial role in assessing the impact of patch geometry and different treatments on bark recovery. It is essential to test various bark harvesting methods and evaluate the effect of patch geometry in establishing sustainable harvest limits. Non-destructive harvesting practices enable obtaining quality produce on a sustainable basis without harming the trees. In India, no prior studies have addressed this aspect, highlighting the importance of this research in developing sustainable bark harvesting practices for *T. arjuna.*

MATERIAL AND METHODS

The current research aims to investigate the influence of patch geometry and various treatments on bark

recovery in *Terminalia arjuna*. The experiment was conducted at the Forest Products and Utilisation Department within the College of Horticulture and Forestry, Pasighat, Arunachal Pradesh. Bark extraction was performed using two patch sizes on equal-sized trees, and diverse treatments were applied to facilitate faster bark recovery. The assessment of bark healing properties was conducted once every 30 days, measuring the percentage of the recovered bark area. Additionally, disease and pest incidence on the harvested bark patches were carefully recorded.

The treatments were categorized as follows:

Factor A: Patch Geometry

Patch 1 (P_1) = 15 × 10 cm = 150 sq. cm

Patch 2 (P_2) = 25 × 6 cm = 150 sq. cm

Factor B: Application of post-harvest treatments:

T1: Control

T2: Control + Covered with Plastic Cover

T3: Neem Seed Kernel Extract (NSKE) paste application (100%)

T4: Neem Seed Kernel Extract (NSKE) + Covered with Plastic Cover

T5: Bordeaux paste application

T6: Bordeaux paste application + Covered with plastic cover

T7: Turmeric paste

T8: Turmeric paste + Covered with plastic cover

To perform the experiment, narrow and broad patches were demarcated using markers and chalk powder on the bark of the *Terminalia arjuna* tree. A narrow patch of 15 × 10 cm and a broad patch of 25 × 6 cm were then carefully removed with the help of a chisel and hammer. After removing the outer bark, the specified treatments were applied to trees with narrow and broad patches. The narrow patch was left without a plastic covering, while the broad patch was treated with a plastic cover. After a 90-day period of applying different treatments, the bark healing properties were evaluated, and the results were expressed as the "percent area of bark" recovered. Furthermore, observations regarding disease and pest incidence on the harvested bark patches were recorded and subjected to a two-way ANOVA using the OPSTAT program, considering 8 treatments and 2 replications.

Fig. 1. Marking and removal of bark from *Terminalia arjuna*.

RESULTS AND DISCUSSION

Experiment on suitable bark harvesting in *Terminalia arjuna*was carried out for extraction of bark and harvested in two patches size (15×10 cm and 25×6 cm) and post-harvest treatments were imposed for faster bark recovery (wound healing/ rejuvenations). The treatments imposed on extracted patches as well as the geometry of the patch significantly influenced the per cent bark recovery. Pooled over all treatments, a higher bark recovery of *Terminalia arjuna* was observed in narrow patch (P_2= 39.02%) than the broad patch (P_1=36.12). Most of the individuals of *Terminalia arjuna* showed an edge growth type of bark regeneration. As shown in the Table 1 and Table 2.

The good edge growth was noticeable after 3 months of bark extraction. The management treatments imposed on the extracted patches as well as the geometry of the patch influenced the percent bark recovery in *Terminalia arjuna*. In general, the narrow strips (P_2) recorded higher levels of bark recovery than the broader patch (P_1). The maximum bark regeneration was noticed in Bordeaux paste (39.02%) followed by Bordeaux with plastic (36.66%); least was noticed in Control (20.61%). At the end of three months, treatment with Bordeaux paste and Bordeaux with plastic resulted little over 37 per cent of bark recovery and recorded significantly higher bark regeneration than in other treatments. Bordeaux paste and Bordeaux with plastic when applied to the extracted bark, it forms a thick layer than any other treatments. Little differences were observed with narrow strips (P_2) showed higher bark recovery (39.02%) as compared to broader strips (36.12%). Considerable variation with respect to bark recovery in patch geometry was observed. Pooled over all treatments, a higher bark recovery of *Terminalia arjuna* was observed in narrow patch (P_2= 39.02%) than the broad patch (P_1= 36.12%). Hence, treatment with Bordeaux paste (39.02%) with narrow patches could be suggested for higher regeneration of bark in *Terminalia arjuna*. These Techniques can be adopted for commercial scale harvesting of bark from *Terminalia arjuna*. Treatment protocol can be used for faster wound healing and rejuvenation of bark harvesting and sustainable production from *Terminalia arjuna* planation.

After 3 months of bark extraction, noticeable good edge growth was observed. Both the management treatments applied to the extracted patches and the patch geometry influenced the percent bark recovery in *Terminalia arjuna*. Generally, the narrow strips (P_2) exhibited higher levels of bark recovery compared to the broader patch (P_1). Bordeaux paste treatment showed the maximum bark regeneration (39.02%), followed by Bordeaux with plastic (36.66%), while the control group had the least regeneration (20.61%). Considering all treatments together, a higher bark recovery of

Terminalia arjuna was observed in the narrow patch (P_2= 39.02%) compared to the broad patch (P_1= 36.12%). Hence, it is suggested that Bordeaux paste treatment with narrow patches could achieve higher bark regeneration in *Terminalia arjuna*. These techniques can be effectively adopted for commercial-scale bark harvesting from *Terminalia arjuna*. The treatment protocol can expedite wound healing and promote sustainable bark production in Terminalia arjuna plantations.

The research findings demonstrate that bark regeneration in *Terminalia arjuna* is notably faster when Bordeaux paste is applied to narrow patches, aligning with the results obtained by Pandey *et al.* (2011); Hanumantha (2020) which also observed similar responses of bark harvesting in *Cinnamomum zeylanicum*. Specifically, the treatment involving Bordeaux paste with narrow patches showed superior bark recovery compared to other studied diameter at breast height (DBH) classes. Regarding different methods of bark harvesting in various treatments, significant variations in bark recovery were observed. For instance, strip harvesting methods (ranging from 45 to 120 cm in length and 15 to 45 cm in width) reported faster bark recovery, ranging from 18.60 per cent to 39.59 per cent during the initial six months and 31.89 per cent to 38.86 per cent during the subsequent six months, with complete recovery occurring within 18 to 24 months. After one year of bark removal, an average bark recovery rate of 42 per cent was observed. Additionally, the study found that bark removal in a blaze size of 30 × 30 cm during the December months resulted in almost complete recovery of bark. When bark was removed from only 1/4th of the total girth of trees with different lengths (30 cm, 60 cm, and 90 cm), recovery was enhanced compared to ring barking or girdling methods. Moreover, sharp blazes executed during December to March exhibited increased bark recovery (Anon., 2008). These results highlight the significant impact of bark harvesting techniques on the regeneration of bark. The study indicates that harvesting in narrow patches with the application of Bordeaux paste leads to faster bark recovery, underscoring the importance of proper harvesting methods for sustainable bark regeneration in *Terminalia arjuna*.

Table 1: Effect of different post bark extraction treatments and patch geometry on bark recovery in *Terminalia arjuna.*

Factor-1	Factor-2	Bark recovery % after 3 month
Narrow patch (15 × 10 cm)	Control	22.35
	Control + plastic	22.02
	NSKE	31.56
	NSKE+Plastic	29.62
	B.M	39.02
	B.M+Plastic	36.66
	Turmeric	26.41
	Turmeric+ Plastic	26.93
Broad Patch (25 × 6 cm)	Control	20.61
	Control + plastic	21.17
	NSKE	33.39
	NSKE+Plastic	31.49
	B.M	36.12
	B.M+Plastic	35.28
	Turmeric	25.45
	Turmeric+ Plastic	25.85

Table 2: Effect of different post bark extraction treatments and patch geometry on bark recovery in *Terminalia arjuna.*

Treatment	Bark recovery Percentage		
	R_1	R_2	Mean
NT_1	22.00	22.69	22.35
NT_2	21.67	22.40	22.03
NT_3	31.20	31.92	31.56
NT_4	29.23	30.00	29.62
NT_5	38.80	39.23	39.02
NT_6	36.40	36.92	36.66
NT_7	26.15	26.67	26.41
NT_8	26.67	27.20	26.93
BT_1	20.42	20.80	20.61
BT_2	20.80	21.54	21.17
BT_3	33.08	33.70	33.39
BT_4	31.30	31.67	31.49
BT_5	35.83	36.40	36.12
BT_6	35.00	35.56	35.28
BT_7	25.19	25.71	25.45
BT_8	25.77	25.93	25.85
Factors	**C.D.**	**SE(d)**	**SEm±**
Patch Geometry	0.1	0.04	0.03
Treatment	0.2	0.1	0.1
Interaction effect	0.3	0.1	0.1

*NT: Narrow patch Treatment*BT: Broad patch Treatment

Anova Table					
Source of Variation	**DF**	**Sum of Squares**	**Mean Squares**	**F-Calculated**	**Significance**
Replication	1	2.42			
Patch Geometry	1	3.40	3.40	246.06	0
Treatment (T)	7	1,055.81	150.83	10,887.07	0
Interaction	7	19.60	2.80	202.18	0
Error	15	0.20	0.01		
Total	31	1,081.46			

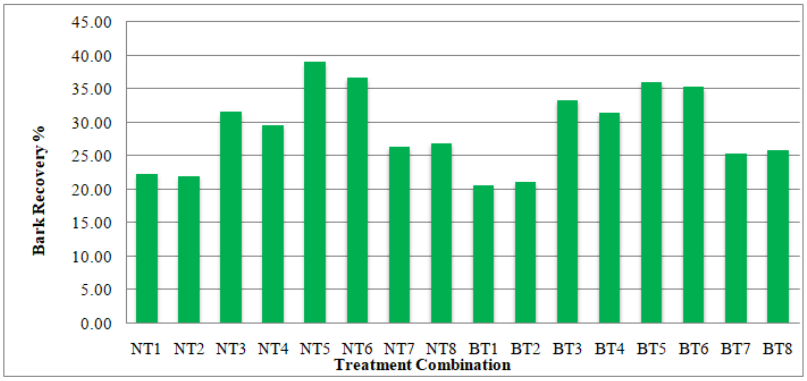


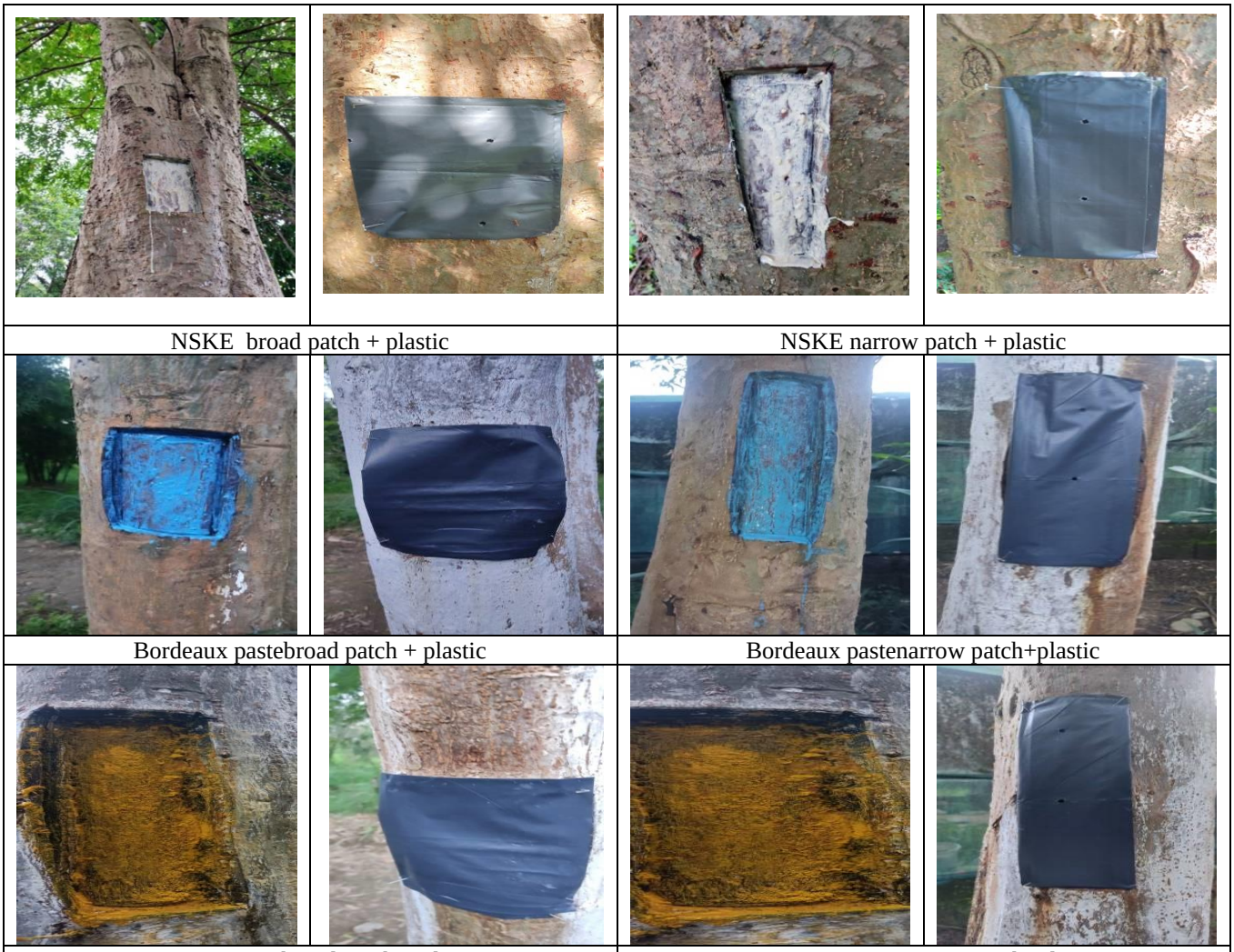
Fig. 2. Effect of different post bark extraction treatments and patch geometry bark recovery in *Terminalia arjuna.*

Control | 2.Neem Seed Kernel Extract

3.Bordeaux paste | 4.Turmeric

Fig. 3. Application of post harvesting treatments.

Control broad patch + plastic | Control narrow patch + plastic



NSKE broad patch + plastic | NSKE narrow patch + plastic

Bordeaux pastebroad patch + plastic | Bordeaux pastenarrow patch+plastic

Turmeric pastebroad patch + plastic | Turmeric paste narrow patch+plastic

Fig. 4. Treatment imposed after post harvesting techniques.

Fig. 5. Recovery of bark at different intervals in *Terminalia arjuna after* 1 month.

Fig. 6. Recovery of bark at different intervals in *Terminalia arjuna* after 2 month.

Fig. 7. Recovery of bark at different intervals in *Terminalia arjuna* after3 month.

CONCLUSIONS

The research findings revealed a variation in bark recovery concerning patch geometry. On average, *Terminalia arjuna* exhibited higher bark recovery in the narrow patch compared to the broad patch when considering all treatments together. Notably, after a 3-month period, treatment with Bordeaux paste demonstrated significantly higher bark regeneration compared to the other treatments. Consequently, it can be recommended that the combination of Bordeaux paste treatment and narrow patches be considered for achieving enhanced bark regeneration in the context of harvesting commercial bark-yielding tree species.

FUTURE SCOPE

These treatment protocols can be adopted in the different parts of the country for sustainable bark harvesting techniques in *Terminalia arjuna*

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Conflict of Interest. None.

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