PROJECT TWO DEFENCE PRESENTATION:

DESIGN OF A MANUAL TEA-LEAF PLUCKING AID
ALLEVIATING OCCUPATIONAL HAZARDS ASSOCIATED WITH TEA-PLANTATION WORKERS IN INDIA

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GOURAB SAHA
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WORKER PROFILE:
Name: Mrs. Nikita Tamang (Temporary)
Age: 28 yrs Experience: 1 month

DIFFICULTIES FACED:
• Pain in hands
• Joint pain in the knee
• Abrasion of fingers
• Discomfort in scalp
• Lower back pain

ADDITIONAL INSIGHTS:
Chose this job because:
• Proximity from home
• Allows her to watch her kids
• Company benefits when permanent

WORKER PROFILE:
Name: Indu Rai (Permanent worker)
Age: 33 yrs Experience: 4 yrs

DIFFICULTIES FACED:
• Pain on hands
• Pain in the knees, thighs
• Abrasion of fingers
• Burning of Scalp
• Lower & upper back pain

ADDITIONAL INSIGHTS:
• Black deposition on fingers that cannot be washed off.
• Alternate uses of doko include: collecting fire-wood for cooking, grass for goats etc, enclosure for chickens

WORKER PROFILE:
Name: Shashikali Rai (Permanent worker)
Age: 45 yrs Experience: 13 yrs

DIFFICULTIES FACED:
• Pain & stiffness on hands
• Pain & stiffness in the knees, thighs
• Abrasion of fingers
• Burning of Scalp
• Lower & upper back pain
• Regular Headaches & burning of eyes

ADDITIONAL INSIGHTS:
• Difficulties multiplied after the age of 40
• Limited load-bearing capacity & mobility
• Stiffness in joints of the limb
**Inferences from Field Study**

**Musculoskeletal Issues**
- Hand fatigue, inflammation and stiffness - sustained contraction of muscles.
- Abrasion of fingers repetitive plucking motion.
- Upper and lower back pain - poor working posture.
- Leg Joint pain, stiffness - long hours of standing & difficult terrain.

**Injuries & Ailments**
- Injuries from falling.
- Sickle injuries during pruning of tea bushes.
- Costochondritis
- Leeches, insect & snake bites.

**Mechanised Tea Harvesting**
- Strong opposition by labour union to replacement of workers by machines.
- Existing machines are not manoeuvrable in hilly terrain.
- Existing machines come with their own set of issues - leaf quality etc.

**Labourer Housing**
- Discomfort due to cramped spaces.
- Poor utilisation & planning of living spaces.
MARKET STUDY - PARALLEL PRODUCTS

A) Kawasaki (gasoline operated): One man plucking machines
   -imgusr.tradekey.com

B) Willam Tea UL750 Selective Tea Harvestor
   -www.cmeri.res.in

C) Falcon Garden Tools, Punjab, India:
   Tea Leaf Plucking Shears
   -www.teaspares.com

D) P.P.P. Jinadasa (Pvt) Ltd, Sri Lanka
   Selective Tea Harvestor
   -www.tmachinery.com
Inferences from Market Study

Musculo-Skeletal Issues:
- Static loading on hands results in fatigue.
- Incorrect load bearing posture such as side bending is not recommended.
- Unbalanced distribution of load on hands and body.

Quality of Plucked Leaves:
There is substantial degradation in the standard of leaves harvested (in comparison to hand-plucking) using the machines to accommodate higher production rates.

Problems with Usage:
- Catcher tray/bag gets stuck in the tree bushes.
- Machines & their accessories are heavy, bulky and difficult to carry.
- Machines are difficult manoeuvre in hilly terrain.
- Require carefully planned paths.

High Initial Investments:
- Apart from the shear-type harvesters, all other types cost upwards of Rs. 1 lakh.
- Large retail gap between categories.
- Regular maintenance of machines have an incurred cost.

Loss of Jobs:
- Hundreds and thousands of house holds are dependant on manual tea plucking for their livelihoods.
- The increased use of tea harvesting machines are replacing the jobs of upto 20 workers at a time.
DESIGN OBJECTIVE

To design a device that is supportive to manual tea plucking. The device must minimise human injury and maintain high leaf standard.

DESIGN BRIEF

The device shall adhere to the following check-points:

1. The device should alleviate musculoskeletal issues associated with manual tea plucking such as muscle & joint pain, inflammation & stiffness.
2. The aid must protect the tea-pluckers hands & fingers from injuries, abrasion, insect bites & deposition of harmful chemicals.
3. Use of the device to pluck tea should not diminish the quality of leaves plucked.
4. The device must be easy to manoeuvre & carry in difficult hilly terrain.
5. The device must be economical to produce.
GATHERING ERGONOMICS INSIGHTS

1. Visually select leaves for plucking
2. Reach for selected leaves
3. Grasping leaves
4. Detaching leaves from stem
5. Holding Leaves
6. Collect Leaves
7. Raise handful of leaves behind head
8. Release leaves onto collection basket
9. Hands down
1. Visually select leaves for plucking
2. Reach for selected leaves
3. Grasping leaves
4. Detaching leaves from stem
5. Holding leaves
6. Collect leaves
7. Raise handful of leaves behind head
8. Release leaves onto collection basket
9. Hands down

**Input:** Safe Effort

**Plucking mechanism**

**Collecting mechanism**

**Output:** Gathered Leaves

Manual Tea Plucking Aid
**ERGONOMIC ISSUES**

1. Plucking of Leaves:
   - a) Repetitive Strain Injury
   - b) Fatigue
   - c) Inflammation

2. Collecting Leaves in hand:
   - Sustained contraction of muscles

3. Environment:
   - a) Absorption of Alkaloids & pesticides
   - b) Insect & snake bites

**DESIGN INSIGHTS**

1. Plucking Component
   - Effort distributed over more muscles is advisable.
   - Dynamic 2 handed plucking motion is recommended.
   - Eliminating unnecessary motions will reduce the effort required.

2. Collecting Component
   - Should not get caught in the tea bushes
   - Should not obstruct device from plucking
   - Avoid

3. Protective Component
   - Product weight <1 kg per hand
   - Must allow for air circulation.
   - Protect fingers to elbow.
IDEATION: SPRING TYPE

Hinged Shears – Moving arm Collector

Hinged Shears – Band Collector

Hinged Shears: Locus Contour Collector

C Shaped Shear-Collector
IDEATION: HAND WORN TYPE

2 Hand, Mating Blade Type

Palm Pocket Type

Mounted Guitar Pick Type

2 Finger, Mating Blade Type
IDEATION: ELECTRIC ASSIST

Vertical Axis Electric Shear

Wire Loop Shearing Mechanism

Pick & Place Mechanism

Suction Pump Collection
3 CONCEPT DIRECTIONS

**Concept Direction 1:** Top Collector Type

**Concept Direction 2:** C-Shaped Type

**Concept Direction 3:** Hand-worn Type
CONCEPT DIRECTION 1

Mechanical Assist
Shear, Collection Levels
4 Finger Trigger Actuation
Wire Collection
CONCEPT DIRECTION 1 - CONT'D.

Shear Mech - Tension cables

leaf release mechanism

Orienting Time  Precision Movements  Unreliable Collection  Complexity
CONCEPT DIRECTION 2

- Pre-stressed Frame
- Hinged blade shearing
- Collection Basket
- Larger Muscle Groups
CONCEPT DIRECTION 2 - CONTD.

Unhinged Blades

Bamboo Body, Hinged Blades

Lowered Shear Plane, Scoop

Blade, Collector Slider Mech.

Styrene Mock-up of Slider Mech.

Obtrusive leaves  Collection Efficiency  Precision Required  Learning Curve
Handle Stereotype  Torsion Spring Back  Blade Mount, Scoop  Visibility
Protective Gloves

Wearable Attachment

V-notch Type, Hinged Blade

cotton underside
denim topside
elastic
blade attachment
CONCEPT DIRECTION 3 -CONTD.

Separated Finger Blades

DIY Jeans-Cotton Glove

Curved Blade with teeth

V-Notch Blade finger straps

Hinged V-notch blade

Plucking Force  Constrained Fingers  Torn Leaves  Thumb Intervention
CONCEPT DIRECTION 3 - REFINEMENT

Mimics Std Plucking

Wearable Blade Attachment

Thumb Guard

Adjustable Straps
CONCEPT DIRECTION 3 - TESTING

- Side oriented blade
- Double blade variant
- Center oriented blade

Force Reduction
Comparable Speed
Selective Plucking
Easy Learning Curve
Variants
3 PART BLADE ATTACHMENT

- 3 Part Blade Attachment
- Blade Replacability
- Slots & Snaps
- Velcro Fasteners
THUMB PROTECTION

- Acrylic PP thumb guard
- Nylon-fabric velcro straps
- Tough Leather Guard
- SS fiber layer
- Thick fabric outer
- Fabric under layer
- 3-segment guard
- Acrylic PP thumb guard
PRE-FINAL DESIGN PROPOSAL

- Thick fabric outer
- Blade Attachment
- Leather Thumb-Gaurd
- Protective Gloves
- Half-razor
- Slot for razor
- Alkaloid collection space
- Slots for straps
PRE-FINAL DESIGN PROPOSAL

- Standard half-razor (replaceable)
- Alkaloid collection space
- Wall to hold blade
- Polypropylene body
- Slot for straps
- Contoured base sits on index finger
- Press for blade release
1. No. of test subjects: 5 tea pluckers
2. Duration of training with prototypes: 30 minutes / subject
3. Comparison: 20 min hand plucking v/s 20 min proto-plucking
4. Quantitative data: Weight of Plucked leaves (Grams)
5. Qualitative data: Plucking Effort required (Scale of 5), Pain Experienced whilst plucking (Scale of 5), Quality of plucked leaves (Scale of 5)
OBSERVING USER BEHAVIOUR

Hand Plucking  Pulling Off Leaves  Holding Collected Leaves  Single-hand Use of Proto
<table>
<thead>
<tr>
<th>Sl #</th>
<th>Name (M/F)</th>
<th>Age</th>
<th>Experience</th>
<th>Weight of Plucked Leaves (grams)</th>
<th>Average Plucking Rate (grams/min)</th>
<th>HAND-PLUCKING (20 MINUTES)</th>
<th>PROTO-PLUCKING (20 MINUTES)</th>
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<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Kirpa Hasda (F)</td>
<td>27</td>
<td>5 Yrs</td>
<td>1200</td>
<td>60</td>
<td></td>
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<tr>
<td>2</td>
<td>Nancy Khardiya (F)</td>
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<td>6 Mns</td>
<td>2000</td>
<td>100</td>
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<tr>
<td>3</td>
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<td>1200</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Hasina Sheikh (F)</td>
<td>35</td>
<td>17 Yrs</td>
<td>1500</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Anand Sheikh (M)</td>
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<td>2 Mns</td>
<td>1500</td>
<td>75</td>
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<td>25</td>
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<td>400</td>
<td>20</td>
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<td>4</td>
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<td>35</td>
<td>17 Yrs</td>
<td>500</td>
<td>25</td>
<td>1</td>
<td>4</td>
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<tr>
<td>5</td>
<td>Anand Sheikh (M)</td>
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<td>30</td>
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# COMPARISON OF PLUCKING EFFORT

<table>
<thead>
<tr>
<th>SI #</th>
<th>Name (M/F)</th>
<th>Age</th>
<th>Experience</th>
<th>Hand-Plucking Plucking Effort (Score/5)</th>
<th>Proto-Plucking (20 MIN) Plucking Effort (Score/5)</th>
<th>Percentage Decrease</th>
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<td>Kirpa Hasda (F)</td>
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<td>2</td>
<td>50.00%</td>
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<td>66.67%</td>
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<td>60.00%</td>
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<tr>
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<td>Hasina Sheikh (F)</td>
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<td>17 Yrs</td>
<td>4</td>
<td>1</td>
<td>75.00%</td>
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<td>75.00%</td>
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</table>

**Average Reduction % = 65.33%**

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**Legend for Scores - Plucking Effort**

<table>
<thead>
<tr>
<th>Score/5</th>
<th>Represents</th>
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<tbody>
<tr>
<td>1</td>
<td>Minimal effort required to pluck leaves</td>
</tr>
<tr>
<td>2</td>
<td>Lesser effort required to pluck leaves</td>
</tr>
<tr>
<td>3</td>
<td>Fair amount of effort required to pluck leaves</td>
</tr>
<tr>
<td>4</td>
<td>More effort required to pluck leaves</td>
</tr>
<tr>
<td>5</td>
<td>Maximum effort required to pluck leaves</td>
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# COMPARISON OF PAIN EXPERIENCED

<table>
<thead>
<tr>
<th>Sl #</th>
<th>Name (M/F)</th>
<th>Age</th>
<th>Experi</th>
<th>HAND-PLUCKING (20 MIN) Pain Experienced (Score/5)</th>
<th>PROTO-PLUCKING (20 MIN) Pain Experienced (Score/5)</th>
<th>PERCENTAGE DECREASE</th>
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<td>1</td>
<td>66.67%</td>
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<td>4</td>
<td>1</td>
<td>75.00%</td>
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<td>3</td>
<td>1</td>
<td>66.67%</td>
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<td>17 Yrs</td>
<td>5</td>
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<td>80.00%</td>
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**AVERAGE REDUCTION % = 71.00%**

## LEGEND FOR SCORES - PAIN EXPERIENCED

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<th>Score/5</th>
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<tbody>
<tr>
<td>1</td>
<td>Minimal pain or discomfort experienced</td>
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<td>2</td>
<td>Lesser pain or discomfort experienced</td>
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<td>3</td>
<td>Fair amount of pain experienced</td>
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<tr>
<td>4</td>
<td>More pain or discomfort experienced</td>
</tr>
<tr>
<td>5</td>
<td>Maximum pain or discomfort experienced</td>
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</table>
## COMPARISON OF LEAF QUALITY

<table>
<thead>
<tr>
<th>SI #</th>
<th>Name (M/F)</th>
<th>Age</th>
<th>Experience</th>
<th>HAND-PLUCKING (20 MIN)</th>
<th>PROTO-PLUCKING (20 MIN)</th>
<th>PERCENTAGE INCREASE</th>
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<tr>
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<td>Leaf Quality (Score/5)</td>
<td>Leaf Quality (Score/5)</td>
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<td>33.33%</td>
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<td>0.00%</td>
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<td>33.33%</td>
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### AVERAGE IMPROVEMENT % = 20.00%

### LEGEND FOR SCORES - LEAF QUALITY

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<th>Score/5</th>
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<tr>
<td>1</td>
<td>Poor leaf quality</td>
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<tr>
<td>2</td>
<td>Below average leaf quality</td>
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<tr>
<td>3</td>
<td>Satisfactory leaf quality</td>
</tr>
<tr>
<td>4</td>
<td>Good leaf quality</td>
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<tr>
<td>5</td>
<td>Very good leaf quality</td>
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## COMPARISON OF WEIGHT PLUCKED

<table>
<thead>
<tr>
<th>Sl #</th>
<th>Name (M/F)</th>
<th>Age</th>
<th>Experience</th>
<th>Manual Plucking (2 handed) 20 min</th>
<th>Manual Plucking (1 handed) 20min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Weight of Plucked Leaves (grams)</td>
<td>Weight of Plucked Leaves (grams)</td>
</tr>
<tr>
<td>1</td>
<td>Kirpa Hasda (F)</td>
<td>27</td>
<td>5 Yrs</td>
<td>1200</td>
<td>600</td>
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<tr>
<td>4</td>
<td>Hasina Sheikh (F)</td>
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<td>750</td>
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<td>21</td>
<td>2 Mns</td>
<td>1500</td>
<td>750</td>
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<table>
<thead>
<tr>
<th>Sl #</th>
<th>Prototype Plucking (1 handed) 20min</th>
<th>Percentage Decrease 1</th>
<th>Percentage Decrease 2</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Weight of Plucked Leaves (grams)</td>
<td>(Comparison Vs 2 Handed)</td>
<td>(Comparison Vs 1 Handed)</td>
</tr>
<tr>
<td>1</td>
<td>500</td>
<td>58.33%</td>
<td>16.67%</td>
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<tr>
<td>2</td>
<td>500</td>
<td>75.00%</td>
<td>50.00%</td>
</tr>
<tr>
<td>3</td>
<td>400</td>
<td>66.67%</td>
<td>33.33%</td>
</tr>
<tr>
<td>4</td>
<td>500</td>
<td>66.67%</td>
<td>33.33%</td>
</tr>
<tr>
<td>5</td>
<td>600</td>
<td>60.00%</td>
<td>20.00%</td>
</tr>
</tbody>
</table>

**Average Reduction % =**

- **65.33%**
- **30.67%**
SAFETY HAZARDS

• Extremely sharp SS razors would slash through their skin if the pluckers absentmindedly brush their face or body to remove insects.

BLADE ATTACHMENT

• Makes approach to leaf difficult hence yielding a low collection efficiency - it is difficult to grip the leaves once they are cut.

• Decreasing height would ensure more plucking force applied at shear junction.

FASTENING BANDS

• Elastic straps taken for the field test eventually loosen and rotate about the index finger and thumb.

TRAINING TIME

Workers need to get accustomed to the aid, prototypes could be deployed for 30 days for deeper insights & more accurate data on usage patterns.
FINAL DESIGN PROPOSAL
Replaceable PP Blade
Adjustable Nylon-Velcro fastening straps
Half round snap-lock
PP Attachment Body
Blade Guide Slots
Slots for fastening
Alkaloid collection gap
Replaceable PP Blade
Adjustable Nylon-Velcro fastening straps
Half round snap-lock
Slots for fastening
Wearable Blade Attachment

Recommended: Protective Nylon-Latex Gloves

Snap-locked PP Blade
Wearable Blade Attachment

Recommended: Protective Nylon-Latex Gloves

Adjustable Nylon-Velcro fastening straps

Thin Plastic Inner Layer

Synthetic Leather Layer

Thumb Guard

Wearable Blade Attachment
Recommended:

1 Pair Protective Nylon-Latex Gloves
1 Pair Wearable Blade Attachment
1 Pair Thumb Guards

Replaceable PP Blades

Recommended:
1 Pair Protective Nylon-Latex Gloves
Eliminate blade safety concern completely.
Designing for better collection efficiency.
Address static contraction of muscles.
Strain-gauge testing for plucking effort.
Business model & Branding.
A preliminary ergonomic study on tea plucking operations.
Sen, R. N.; Ganguli, A. K.; Roy, G. S.; De, A.; Chakraborty, D.

Tea Statistics India (upto 2013)
www.teaboard.gov.in/

Darjeeling tea industry unfair to tea-pluckers

Tea-plucking machines in India threaten Assam livelihoods

Struggle of Tea Plantation Workers in North East India
www.amrc.org.hk/node/1001

New ways and means to increase tea production

Tea Processing
en.wikipedia.org/wiki/Tea_processing

Developing Situations of Tea Plucking Machine
Yu Han, Hongru Xiao, Guangming Qin, Zhiyu Song, Wenqin Ding, Song Mei

The Life of a Tea Plucker
www.frontiercoop.com/sourcing/plucker.html

Tea Growing Regions
www.indiatea.org/tea_growing_regions.php

Selective Tea Harvester
http://www.tmachinery.com/selective-tea-harvester.html

Production of Quality Tea Crop
http://www.ihbt.res.in/TIM/production.html

Effects of plucking methods on yield and quality of black tea
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