Four ergonomics interventions for saffron-picking

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1 Related work

Little ergonomics research has been done on saffron-picking, but much has been done on similar tasks. A main risk factor in saffron-picking is the assumption of stooped postures. Jobs where these stooped postures are used for extended periods are considered types “stoop labor". By looking at other forms of stoop labor, we were able to identify many opportunities for making saffron-picking safer while maintaining or improving productivity.

1.1 Rest breaks

Considering the level of difficulty to implement ergonomic solutions, one should, first, evaluate a worker’s work/rest schedule and determine if it is applicable to the strenuous manual material handling tasks observed. There is sufficient research that suggests that job redesign strategies and alternative work/rest schedules can be effective in improving comfort, health, and productivity {Dababneh, Swanson &Shell, 2001}. Although most would assume workers take rest breaks, rest breaks can occur at an inefficient interval which can negatively affect a worker’s performance and overall productivity.

It has been found that in addition to lunch breaks, hourly rest breaks were beneficial for a workers’ well being and that these breaks have no adverse effect of production and tended to increase worker performance {Dababneh, Swanson &Shell, 2001}. In situations where ergonomic solutions are too expensive or difficult to implement, modifying patterns of work and rest may be feasible for employers and beneficial for employees {Faucett, Meyers, Miles, Janowitz, & Fathallah, 2007}

Studies have shown that workers can tolerate certain levels of fatigue and will protect their output from declining by investing more resources and working harder, and this is true until fatigue reaches a level where one cannot work any harder and their performance would deteriorate {Dababneh, Swanson &Shell, 2001}. When considering the frequency and duration of rest breaks over the course of a work day, workers preferred longer rest breaks every hour versus shorter rest breaks every half-hour and overall with short rest breaks, worker’s showed increase task interruption over a period of time as a result of the fragmentation of the work day.

1.2 Prone platforms

One line of research has developed moving platforms that we’ll call “prone platforms". Instead of stooping, people lie down on their stomachs on these platforms. Research on these has been going on for fifty years (Meyer, 2004).

Meyer and Radwin (2006) compared stooping with using a prone platform. They simulated stoop labor. They constructed a moving conveyor belt with holes into which participants placed balls. They ran the conveyor belt faster when participants were

using the prone platform as earlier studies had shown prone platforms to increase picking-speed.

They found muscle activity during the simulated stooping task to be lower for the prone platform in the legs and back. There was no significant difference for the arms. Heart rate was also lower for the prone platform.

2 Rest breaks

We recommend that saffron workers should take a 9-minute rest breaks every 51 minutes of work, based on the evidence that hourly breaks significantly more beneficial than half-hourly breaks because of the maintainability of production rates and the decrease in task interruptions (Dababneh, Swanson &Shell, 2001). Additionally, hourly breaks also have shown to decrease leg discomfort over the course of the work day. Followers of Islam pray five times a day, right before sunrise (Fajr) ~5:15am, at noon (Dhuhr) ~12:45pm, in the late afternoon (Asr) ~4:15pm, right after the sun sets (Maghrib) ~6:55pm, and before going to bed (Isha) ~8:15 pm (Alnaseej 2010). Rest breaks could be incorporated to fit the prayer schedule to further encourage workers to take their much-needed rest.

3 Cut and Pick Tool

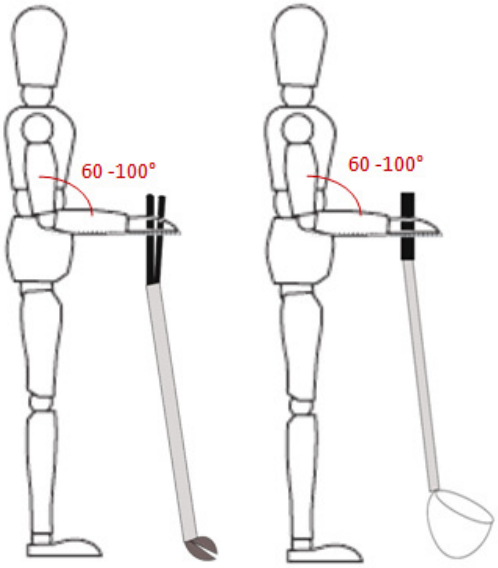
Our group wanted to mainly focus on ways that saffron –pickers would not have to expose their body to awkward, painful postures in the first place. One way is through the use of a set of hand tools that will eliminate the need to bend down. One hand holds a saffron-cutting tool, while the other hand holds a stick with a basket at the end. To construct the prototypes for these two instruments, pre-existing devices were purchased and modified. One of the devices is the the Arcoa “EZ Reacher” hand grabber and the other apparatus is a set of pruning scissors. The pruning scissors were attached to the end of the hand grabber so that when the grabber’s handles are squeezed together, the scissors close, snipping whatever was between them. Duct tape was used to secure the two devices together; duct tape also was used to decrease the grip span of the prototype, althought more adjustments would need to be made to the design if it were to actually be implemented in the fields. The creation of the stick with the basket at the end was simple and could be recreated in many other ways, as long as the simple structure and features are maintained. Our prototype used a stick that was only 1 inch in diameter (to save on costs), and a plastic bag with a wire taped around the opening (to keep the bag constantly open.) It is recommended that these tools be made locally with local materials, to both save on costs and be more user-specific.

3.2.1 Adjustments

First, for cutting tool, the handle should be vertically extended from the rest of the tool, instead of at the 100 degree angle seen in the prototype. This will allow the device to be in the midline of the body, as well as permitting the user to utilize a power grip to maximize grip strength. The handle itself should only have a grip span of 2 inches in diamter before the two parts of the grip are flexed together, and should not be smaller than 1.5 inches after flexed. All of these adjustments will minimize wrist deviation. For the basket tool, the handle should also be vertical and have a grip two inches in

diameter. A slender stick could still be used, as long as at the top of the stick, where the user will grab it, it is thicker. (Tape, rubber, and other materials can make this part thicker.)

Both hand tool prototypes also need to be adjusted in length. When held perfectly vertically straight, the cutting tool should keep the elbow flexed in 60-100˚. The basket needs to be held the same way. Because the height of the tool would affect the flexion of the elbow, the; the hand tool's size needs to come in a variety of heights, or be height adjustable, to accommodate each user.



Power grip – *photo courtesy of http://technizzel.com/wp-content/uploads/2007/08/prosthetic-arm-3.jpg*

3.2.2 Training

It is important that saffron pickers are trained on how to hold the tools in the power grip manner discussed. Objects can only have ergonomic improvements if they are handled in the correct way.

(Photos of prototypes on following page.)

Cutting Tool

Close-up of incorrect handle on prototype

Cutting Tool from front view

Basket Tool

Close-up of pruning scissors

3.3 Sitting Platform

Another way to eliminate the stooping posture for saffron pickers is through the use of a sitting platform in combination with the cut and pick tool. The platform will be high enough to be positioned above the rows of saffron plants. The sitting platform will allow the user to be closer to the ground, so they can have more precision cutting the flowers if using the tools while standing poses precision and aiming problems. When the user is sitting on the platform, the saffron plant will be right in front of them and they can pick the flowers by using the cut and pick tool. While using the sitting platform and the cut and pick tool, the user will be able to keep their back in a low degree of flexion and most of the awkward postures that are associated with saffron picking can be eliminated.

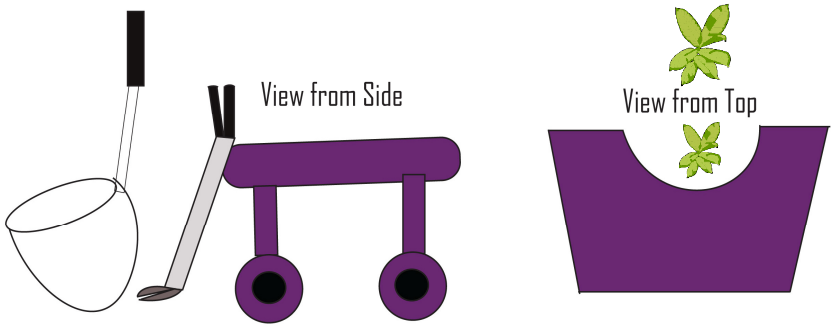
3.3.1 Height of Platform

The height of the saffron plant can vary from 10cm to 30cm therefore, the species of saffron plant used in the fieldwill determine the final height.t It will have wheels that will allow the user to move over the row of plants.

3.3.2 Wheels

In the fields, different types of wheels may have to be tested to determine the ones that work best in an agricultural setting.

3.3.3 Diagram of Sitting Platform



4 Prone platform

Prone platforms can allow almost the entire body to rest in a neutral posture. The only part of the body that should be working most of the time in a prone platform is the arms. This can make the work much more productive and safe for everybody. It can also allow certain people who previously couldn't pick saffron, such as the blind and paraplegic, to pick saffron.

Because of these benefits, prone platforms are gaining popularity in strawberry-picking. Simply purchasing these platforms is not feasible, however, as all of the available platforms on the market are very expensive.

We thus recommend that prone platforms be built locally, either by the saffron-pickers or by local craftsmen. There are currently no systematic ergonomic guidelines or instructions for building them, however, so we created them.

Based on a review of the design of many prone platforms (Meyer, 2004), on our general ergonomics knowledge and on the layout of the saffron fields, we developed eight points to consider in their design. These are the direction of movement, the overall body posture, the chest support, the arm rest, the headrest, the basket, the method of propulsion and multiple-person platforms.

We present the eight points below with along with suggestions of how to construct the various features out of standard lumber. After that, we provide an example of how to construct the base out of standard lumber. We then present dimensions relevant to the construction of the platform.

4.1 Direction of movement

The platform can move with the head first or with the feet first. In most existing prone platforms, the head is first as this is easier to self-propel. Having the feet first can make picking easier, however. The human field of vision extends further below our eyes than above, so prone platforms that move feet-first allow the user to see what is ahead rather than what is behind (Meyer, 2004).

We recommend that all prone platforms intended to be self-propelled be moved head-first. Feet-first movement should be considered when external propulsion is available, but it is not necessary.

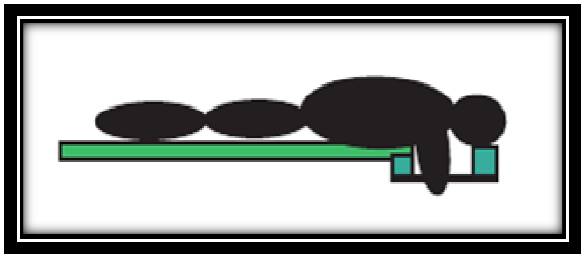
4.2 Body posture

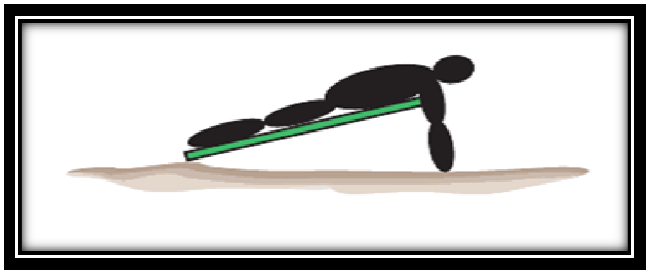
Three main postures are possible: lying flat, bending at the hips and bending at the hips and knees.

4.2.1 Lying flat

The first and simplest posture is lying perfectly flat. The advantage of this is the ease of construction; a platform supporting this posture can be made of one sheet of plywood with two corners cut out to allow for arm movement.

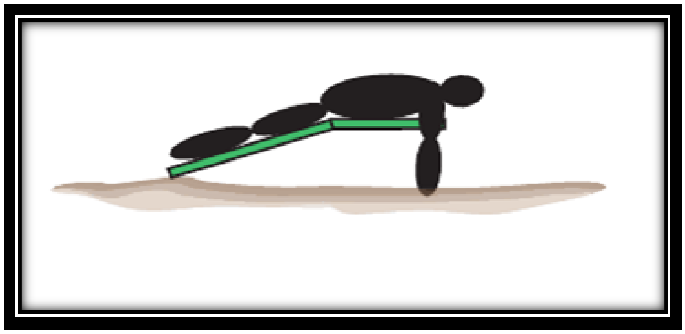
The disadvantages are comfort and difficulty of self-propulsion. While this posture is less strenuous than the stooping posture, it is not as good as the other two that we present. For reasons that we discuss in previous sections, the chest region of the platform must be high to the ground. If the platform is flat, self-propulsion will thus difficult because the feet cannot touch the ground. The platform can be mounted at an angle to allow self-propulsion if users can be prevented from sliding off; a cushion can help with this.





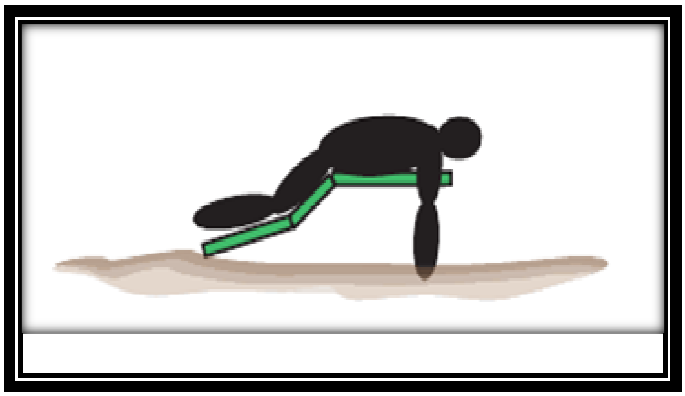
4.2.2 Hips bent, knees straight

This second posture is bending the hips but not the knees. It has the advantage of self-propulsion and the disadvantages of comfort and complexity of construction. It can be self-propelled because it allows the feet to reach the ground while placing the chest high above the ground. It it is not as comfortable as the third posture and needs to be sized more carefully than the first. It can be constructed with two pieces of plywood mounted at an angle, and it needs to be sized appropriately for users' torso, neck and head heights.



4.2.3 Hips and knees both bent

The third and preferred posture involves bending with the hips and knees. This posture is similar to the one that the body takes during zero-gravity. It is comfortable and can be self-propelled, but it is most difficult to construct. It requires three pieces of plywood: One supports the torso, one supports the thighs and one supports the lower legs. It is more sensitive to the dimensions of the legs than the second posture.



4.3 Chest support

The chest must be supported without restricting movement of the arms. Thus, there must be support for the chest, but the region that supports the chest must not be wide enough to interfere with the arms. We learned while constructing the prototype that the limit of this width is easy to overestimate. Particular attention should be paid to this dimension when dimensions are measured on people, and measurements of this dimension should err on the small side.

The chest support also needs to be raised a few centimeters above the rest of the platform in order to support the natural curvature of the chest. In most cases, the adjustment will be small enough to be made by stacking some wood there temporarily.

4.4 Arm rest

The user's arms will normally be hanging down from the platform and picking flowers, but it is important that he or she be able to rest the shoulders, arms and hands from time to time. Thus, there should be some sort of arm rest that can be used for short rests but does not interfere with arm movement during work. A simple way of doing this is making the platform wider in the stomach region.

4.5 Headrest

A headrest should support the head to allow neutral and relaxed posture of the head and neck without obscuring vision. This could be made of two long pieces of wood screwed into a block of wood below the main platform and extending to the forehead with a piece crossing them to support the forehead.

4.6 Basket

The prone platform should incorporate a basket for storing picked flowers in convenient reach of the arm. This makes each picking motion much shorter and less strenuous and removes the need to move the flower container. This feature can be a very easy way of improving productivity.

4.7 Method of propulsion

The platform can be propelled by the person lying on it or by an external source. A user can self-propel the platform by pushing his feet against the ground. The platform can be externally propelled by another person, farm machinery or farm animals.

If another person is to be used, two handles should extend out of the platform at approximately that person's hip height so he can pull the platform without raising his arms. If this approach is taken, we suggest that one puller be assigned to a group of platforms. He or she can move one platform by a step or two, then move to the next platform, move it a step or two, and so on. Also, platform-pullers and saffron-pickers should switch roles from time to time to vary the type of work they do.

Many different types of farm machinery and animals could be used to propel the platforms, so we won't discuss how to attach the platforms to all of the different types. We have a few general recommendations, though. First, any engines must be far enough in front of the platforms that the people on the platforms don't inhale noxious exhaust fumes. Second, consider connecting a series of platforms side-by-side so one vehicle or animal can pull many platforms.

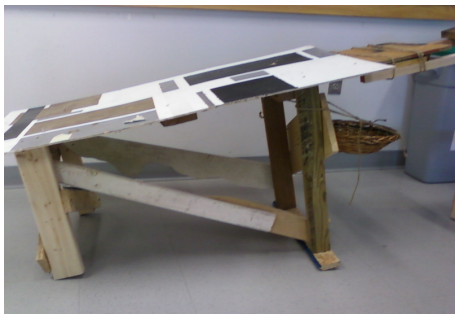
Self-propulsion may be less expensive than external propulsion, but it will be harder to size platforms appropriately for self-propulsion, and self-propulsion will be more strenuous for the pickers.

The feet have to touch the ground for self-propulsion to be possible. For a lying down posture, this means that the plywood panel has to be just a bit shorter than the user's height. For the hips bent, knees straight posture, this means the overall height and angle of the two plywood panels has to allow the feet to touch the ground but not go too low. For the hips and knees both bent posture, the panel supporting the legs must be the length of the lower leg and end at a height slightly above the ground. It could be angled in order to allow this.

Because external propulsion places the feet on the ground, the legs have to be spread in order to avoid damaging the saffron plants behind the platform. Pieces of wood should extend normal from the platform in the leg region in order to spread the legs just enough to clear the saffron plant.

We recommend external propulsion. It simplifies sizing as the feet do not have to touch the ground and reduces strain on the legs by not requiring them to be spread and not requiring them to move the platform.

Prone Platform Prototype from different angles



4.8 Multiple-person platforms

It is easier and cheaper to construct one platform for multiple persons than to construct than to construct one for each of them, but this can make sizing more difficult. In order to construct such a platform, just use wider pieces of plywood make more chest-supports and add more structural support as necessary. One must consider, however, that all of the people using this platform may not have the same body dimensions and may require platforms of otherwise different size.

4.9 Construction of the base

We've developed a very basic idea of how to construct the wheels and base out of wood and screws or nails. For ideas on how to construct the other features, see the sections above that correspond to those features.

Note that we are not expert engineers or woodworkers. We present these directions to convey the form of these platforms, to demonstrate their simplicity and to serve as a prototype for initial testing. We suggest consulting expert woodworkers in order to determine how to construct the platforms more efficiently.

4.9.1 Chassis

Mount four wheels on a rectangular frame of wood. We'll call this frame the chassis. We have not looked into what sort of wheels would work with the soil, but a reasonable type of wheel to choose is any type that is currently used on saffron farms.

Attach at least four vertical pieces to the chassis. These should extend up from the chassis and not down. The other ends of these four pieces should attach to the platform proper.

There should be at least 30 cm of clearance below the chassis in the center of the platform so it does not destroy unpicked saffron (Kafi et al., 2006). Such large clearance is theoretically not be necessary for head-first direction platforms as saffron will generally be picked before the platform moves over it, but we still recommend it as people may move the platform over un-picked saffron either by accident or for a reason that we have not thought of.

4.9.2 Platform proper

The platform proper can be made of plywood reinforced with beams of wood underneath. Nails or screws attaching the plywood to the beams should be inserted with their heads on the plywood side and their points inside the beam in order to avoid poking users.

Attach the platform to the vertical pieces at these beams. After the chassis and platform have been attached, diagonal pieces can be placed in areas that need additional stability.

Note that the platform does not have to be flat; it can be slanted between the head and foot ends, though it probably should not be slanted from side to side. Knowing this should make the platform easier to build.

Cushioning can be placed on top of the platform, but it should be no more than a couple centimeters thick.

4.9.3 Adjustments for different postures

Platforms with multiple pieces of plywood that support the postures with bent knees or hips can be made by constructing an appropriately shaped frame out of beams and mounting the plywood on top. The different pieces of plywood do not have to align perfectly flush with each other. It may, in fact, be better that they do not as this may make the corner less sharp and reduce pressure points.

For the lying down posture, only four vertical pieces are needed. For the hip or knee bent postures, more vertical pieces will be needed.

4.9.4 Facilitating self-propulsion

For any self-propelled platform, the rear pair of vertical pieces is not necessary as the feet need to be low enough to the ground to push against it.

If the wheels are large, it may be necessary to mount the wheels above the chassis in order that the feet can touch the ground.

4.9.5 Minor adjustments after construction

The platforms can be adjusted slightly by users for body curves or for different users by placing wood or cushioning on top of the platform.

4.10 Measurements

We have identified dimensions relevant to the prone platform, but we have not looked up measurements for them. If these measurements are looked up in tables of anthropometric data, try to choose anthropometric data of Iranians or a similar group, and make sure to take data for a wide range of people, including children, small women and large men.

Because our platform is so simple to build, however, looking up measurements may be unnecessary; if the platforms can be built locally, they can be sized to specific workers.

Dimensions for all Postures

Dimension of platform	Reasoning
Chest-support width	Chest width
Chest-support height	Shoulder to hand
Extension of the chest-support beyond the rest of the platform	Just enough to allow free shoulder movement
Width of the platform	Wide enough to serve as an arm rest, wider if multiple people will be on the platform at once
Distance to headrest	Sternum to forehead
Width of headrest	Wide enough not to obscure vision
Added height to chest support	Neutral alignment the upper torso, probably a few centimeters
Height of basket above ground	High enough not to touch the saffron plant
Wheel spacing	Saffron row width

Specific to hip and knee both straight postures

Dimension of platform	Reasoning

Length of platform	Distance from feet to neck at minimum

Specific to hip bent, knee straight postures

Dimension of platform	Reasoning
Length of top piece of wood	Hips to neck
Length of slanted piece of wood	Hips to knees, ending above knees

Specific to hip and knee both bent posture

Dimension of platform	Reasoning
Length of thigh support	Hip to knee distance
Length of lower leg support	Knee to ankle distance

Specific to self-propelled platforms

Dimension of platform	Reasoning
Height of the back of the platform	Low enough that the feet can push against the ground

5 Testing

For each of our solutions, we recommend that the change in productivity after their introduction be measured. Picking speed in weight per time per person is a sufficient measure.

Tests of their musculoskeletal risk are unnecessary for rest breaks. For rest breaks, they are unnecessary because the literature shows that increasing rest breaks decreases musculoskeletal risk.

We have performed tests on the cut and pick tool that suggest that it improves posture over traditional stooping. Considerable research has shown that prone platforms reduce musculoskeletal risk. We have reasoned that the sitting platforms should improve posture.

We already predict that these three interventions will improve the saffron-picking task ergonomically, but more testing may identify opportunities for improvement that we had not noticed.

Further tests of musculoskeletal risk would be a good idea for the prone platform, sitting platform and cut and pick tool . For the sitting platform and cut and pick tool, REBA or RULA can be used. Posture-targeting methods cannot be used for the prone platform. Past research on prone platforms has used EMG Meyer and Radwin (2006), so we suggest using EMG to test our design.

6 Going forward

We have presented three ergonomic interventions to reduce the musculoskeletal risk of saffron picking while maintaining or improving the level of productivity.

We recommend that each of our suggestions be implemented in trial farms and tested according to our recommendations in section

Dimension of platform	Reasoning
Chest-support width	Chest width
Chest-support height	Shoulder to hand
Extension of the chest-support beyond the rest of the platform	Just enough to allow free shoulder movement
Width of the platform	Wide enough to serve as an arm rest, wider if multiple people will be on the platform at once
Distance to headrest	Sternum to forehead
Width of headrest	Wide enough not to obscure vision
Added height to chest support	Neutral alignment the upper torso, probably a few centimeters
Height of basket above ground	High enough not to touch the saffron plant
Wheel spacing	Saffron row width

Specific to hip and knee both straight postures

Dimension of platform	Reasoning
Length of platform	Distance from feet to neck at minimum

Specific to hip bent, knee straight postures

Dimension of platform	Reasoning
Length of top piece of wood	Hips to neck
Length of slanted piece of wood	Hips to knees, ending above knees

Specific to hip and knee both bent posture

Dimension of platform	Reasoning
Length of thigh support	Hip to knee distance
Length of lower leg support	Knee to ankle distance

Specific to self-propelled platforms

Dimension of platform	Reasoning
Height of the back of the platform	Low enough that the feet can push against the ground

5. For any of suggestions that prove successful, our guidelines should be translated to Farsi and distributed widely.

Simple language with pictures should be used so that they can be understood by laypeople. Most people in Iran can read and write (CIA,), but it is still important that the guidelines be understandable by people with only basic reading ability so that nobody is excluded.

They should be sent to everyone as many people are involved in the saffron harvest. It is important that saffron-pickers and managers receive the guidelines. For the arm-extender and prone platform, it is important that woodworkers receive the guidelines as they will be most able to construct the tools for saffron-pickers.

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