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Scope of mechanical harvesting of Saffron for economic development of farmers in Kashmir Region of Jammu & Kashmir, India

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ABSTRACT

Saffron a perennial herb, well-known for its aroma and used for flavouring, is a culinary delight. It is an important commodity and is of great significance in the agricultural economics of Jammu and Kashmir. Saffron is popularly known as Red Gold. The commercial part of saffron is Stigma. Saffron is used in industries like food, pharmaceutical, cosmetic and perfumery as well as in the textile dyes. In India most of the saffron production is limited to the state of Jammu and Kashmir. Besides, having tremendous medicinal values, saffron has traditionally been associated with the famous Kashmir cuisine and undoubtedly represents the rich cultural heritage of Kashmir. This legendry crop is under threat of extinction and warrants collective attention of Mechanisation, researchers, farmers and policy makers. In the production process of Saffron spice, flower harvesting and stigma separation are the most challenging phases of the entire process. In this paper, mechanical devices for supporting the human work in harvesting and field tests are provided, presented and described as well. The harvesting device described has a simple design and is capable of performing the cutting procedure with only one actuated degree of freedom.

1. Introduction

Saffron is most expensive spice the world, and the word saffron originated from 12th century old French term saffron, which is derived from the latin word Safranum. Safranum comes from the Arabic word Asfar means yellow. In Sanskrit it has been the name of kumkum & kesar (Katzer, 2001). At present, saffron plant is cultivated in Central Asia, Greece, India, Iran, Italy, Morocco, Pakistan, Spain, Swiss and Turkey. However, Iran and Spain are known as the main saffron producers in the world (Kafi *et al.,* 2002). The saffron flower has three stigmas, which are the most important economic part of the plant and known as saffron. The world's total production of dried saffron is estimated around 300 tons per year (FAO, 2008). In India, the Jammu and Kashmir is the only state that produces saffron with an area of more than three thousand hectares (shown in table 1) with a production of 125 quintals with an average land holding of 0.56 ha which holds a unique distinction of producing Saffron (Crocus Sativus L.) with a history of about 2,500 years (Digest of Statistics, 2008). The time at which saffron was introduced to Kashmir is not precisely known, although evidence from 'Rajatarangini', written by a 12th century poet and historian Kalhana, indicates its presence in Kashmir even before the reign of King Lalitaditya in 750 AD. Saffron originating from the Arabic word 'zafaran' meaning yellow, is a fascinating spice steeped in rich history. Saffron is a high price spice due to much direct labour required for its cultivation, harvesting and handling (Alam, A. 2008). Figure 1 showing manual harvesting of saffron flower Jammu and Kashmir agriculture has an international identity and the world's best saffron is grown in the valley and its major intensity is in district Pulwama and Budgam. Nearly 90% of the total area in the state under the crop is cultivated in Kashmir province only.

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Its cultivation in Jammu division is limited to district Kishtwar only. Saffron is a rain fed crop and the main output of the crop is a dark yellow substance obtained from the flowers called the saffron. The recorded Saffron cultivation and production in Jammu &and Kashmir dating back to year 1980-89 used to be about 300-400 quintals per year while the cultivation has been now reduced to 130 quintals per year (Khanday *et al.,* 2008).

Production trends of saffron production shown in table 2. Saffron has been growing at a rate 1.63 kg per hectare, while in other saffron producing countries of the world, it is relatively more (Anonymous, 2014). Saffron in Kashmir region is grown on an area of about 3,200 ha and its cultivation is not highly mechanized in this day and age, although it requires high labour input during the most important growing phases (Anonymous, 2014).

Figure 1. Manual harvesting of saffron flower in Kashmir, J&K, India.

Table 1. District wise area, production and productivity of Saffron in J&K

District	**Area under saffron, ha**	**Production, MT**	**Productivity, Kg/ha**	**No. oF families involved in saffron cultivation**
Pulwama	3,200 (84.5)	8,014 (84.7)	2.50	9, 000 (55.46)
Budgam	300 (7.9)	750 (7.9)	2.50	1,227 (7.56)
Srinagar	165 (4.4)	404 (4.3)	2.45	732 (4.51)
Kishtwar	120 (3.2)	294 (3.1)	2.45	5,310 (32.72)
Total	**3,785 (100)**	**9,462 (100)**	**2.50 (Ave.)**	**16,229 (100)**
(Source; Directorate of Agriculture, J&K, Nehvi *et al*., 2008)				

Table 2. Saffron yield and production trends in Kashmir region of J&K

Year	**Area (Ha.)**	**Production (MTs)**	**Yield Rate (Kg/ha.)**
1997	5707	15.95	2.8
1998	4161	12.88	3.13
1999	2880	7.65	2.27
2000	2742	3.59	1.88
2001	3075	0.3	1.57
2002	2989	6.5	2.96
2003	2928	5.15	1.66
2004	2436	6.86	3.75
2005	3110	7.04	1.63
2006	3130	6.5	2.25
2007	3010	8.2	2.15
2008	3000	7.7	2.5
2009	3280	9.46	2.34
2010	3785	9.55	2.5
2011	3790	9.85	2.52
2012	3674	10	2.72
2013	3674	11.5	3.13
2014	3674	15	4.08
2015	3674	9.6	2.61
Source: J&K Agriculture Department			

There are limited machines capable of totally mechanizing the crop production of saffron and research till now has always tried to adapt existing machinery to reach individual phase of its cultivation, rather than design specific machines. Most of the field operations for saffron production in the state are carried out manually using Indigenous tools mainly, Khurpi for Weeding, Tangru (small and large for hoeing) and Spade for movement of soil and opening drains.

Tradidtional practices with some mechanization in saffron cultivations

Primary and secondary tillage in seedbed preparation, operations are carried out manually using indigenous tools mainly Ramba or Khurpi for weeding, Tungru–small and large for hoeing and Bel (spade) for movement of soil/opening drain. About 600-625 man-days/ha are used in saffron farming from seedbed to drying. Weeding is most laborious operation in saffron farming in Kashmir requiring 160 man-d/ha (2 weedings). Next labour intensive operations are hoeing (120), picking and separation (120), bed forming and sowing (80), and corm digging (80) which needs to be mechanized. For tillage animal-drawn plough as well as tractor mounted plough and disc harrows are used. In recent past rotovators have come in use for seedbed preparation especially where fine tilth is required. Power tillers have also become popular in Kashmir Valley and are suited to achieving well pulverized seedbed once soil is deep ploughed. In rice-wheat rotation tractor mounted raised bed planters have come in use which can be adopted for bed forming for saffron cultivation. Corms are sown in deep furrows at a spacing of 20 cm made using bullock-drawn plough. Onion/potato/tulip planter can be easily adopted for saffron corm planting. By suitably modifying metering of Raised Bed Planter saffron corm can be planted. It is proposed to adopt wheel hoes, power weeders and power tillers for weeding and hoeing saffron plots.

Potato and groundnut diggers can be adopted for digging and collecting corms with some modifications. Besides size grader electronic corm grader can be developed for grading corms by weight. For drying solar dryers developed are working well, at the same time electric heated saffron dryer is under development (Alam, A. 2008).

***Majour* Concern**

The method of harvesting and stigma separation is time consuming and need maximum labour input and this method employs continuous bending posture which results in heavy work load, musculo-skeletal problems and energy expenditure and sometime there is lack of availability of labour. The unavailability of labour, cause delay in transplanting operation which directly affects crop production and economic condition of the farmer. Therefore development and use of such equipments for small level farmers is necessary to overcome this problem which is which will result in labour and time saving.

Traditional practices of harvesting and picking operations

Saffron flowers are as such normally handpicked in the early morning hours. Work is prolonged and done in bent posture. Effort in this direction will definitely be economically viable as the input cost is very high. These labour days are required in the month of October-November when the farmers are busy. Normally saffron is collected in three pickings at an interval of 4 days starting from last fortnight of October. Flower-picking starts as soon as they appear in the field. The flowers are not picked daily but once in four days, before 9 o'clock in the morning. This should be done on a daily basis because flowers are short lived and if they are left for longer period not only can damaged they get damaged by the quality of saffron also decreases (Mir. 2002 and Munshi *et al.,* 2002).

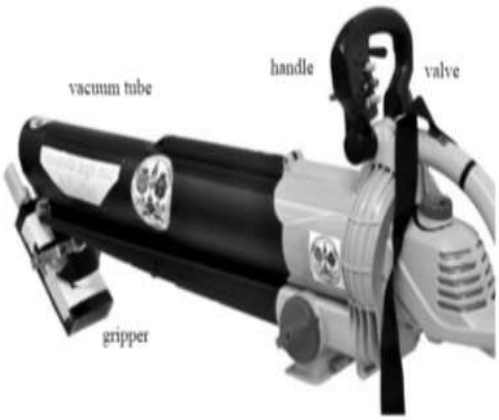

Figure 1(a). The harvesting device

Figure 1(b). The harvesting device in Filed

The flowers should be carried out in clean basket and should not be overloaded as that may prevent free air circulation. This method of flower collecting in Kashmir might cause reduction in quality as well quantity of yield (Ganai,, 2001 and Mir, 2001). These operations can successfully be done with the help of mechanical saffron harvester as shown in Figure 1 (a and b) developed by Monreale *et al.* 2011 in Sardinia (Italy).

In the figure it can be seen the gripper, with two fingers to detach flowers, the body, including the electric motor moving a fan to inhales the detached flowers through the vacuum tube, the handle equipped with a manually operated pneumatic valve to control the pneumatic gripper. The gripper is a one degree of freedom pneumatically actuated device. The pneumatic mini cylinder, supplied at 4 bar relative, is moving an helical cam to convert the translating cylinder rod motion in the helical one of the fingers. This kind of power supply is quite suitable for operation in agricultural fields. The gripper was sensorised for lab tests: two pressure transducers detect the pressure values in the two cylinder chambers, and a wire position transducer allows to know the position of the cylinder rod, linked to the gripper fingers. For the air supply pressure of 4 bar relative, the steady velocity value of the cylinder rod is 0.65m/s reached in 0.06 seconds; this corresponds to a medium acceleration of about 10m/s^2.

The harvesting device was tested taking part in field picking Saffron flowers in open field. Table 1 refers the working condition during the tests on field. In the table are cited four fingers types with covering of different softness. The supply pressure allows an adequate dynamic of the fingers motion, the harvesting times are one-tenth second of magnitude. In the table are also referred the wind velocity, important because of the aerodynamic surface and the light weight of the flowers. One of the test was done in presence of a light rain. It was found that the detached flowers was undamaged by the grasping and detaching procedure and the spice, represented by three red stigmas, is in its place in the goblet. The stems were broken correctly, avoiding damaging bulbs and foils and the average efficiency of successful detaching was 80%.

Other harvesters which can be used for harvesting of saffrons

In Iran a prototype of the machine was designed and constructed that harvests the saffron flower from the stalk. This machine comprises a main farm, power transmission system, and pick up head. In the pickup part, several flexible polymer knives have been used to simulate the pickup task as human hand dose it (Figure. 2). The latter practice is satisfactorily performed with combination of turning and pulling operations similar to human hand.

Table 1. The working condition during the tests on field in San Gavino Monreale in Sardinia (Italy).

Finger type	**Success % at the first detaching**	**detaching time (s)**	**supply pressure (bar)**	**Beaufort number wind velocity**	**Rain**
TYPE 1	80	0, 2	4, 0	1-20Km/h	No
TYPE 2	70	0, 2	4, 0	3-15Km/h	No
TYPE 3	95	0, 2	4, 5	3-15Km/h	Light
TYPE 4	75	0, 2	5, 0	0-0Km/h	No
Source: Manuello *et al.* 2011					

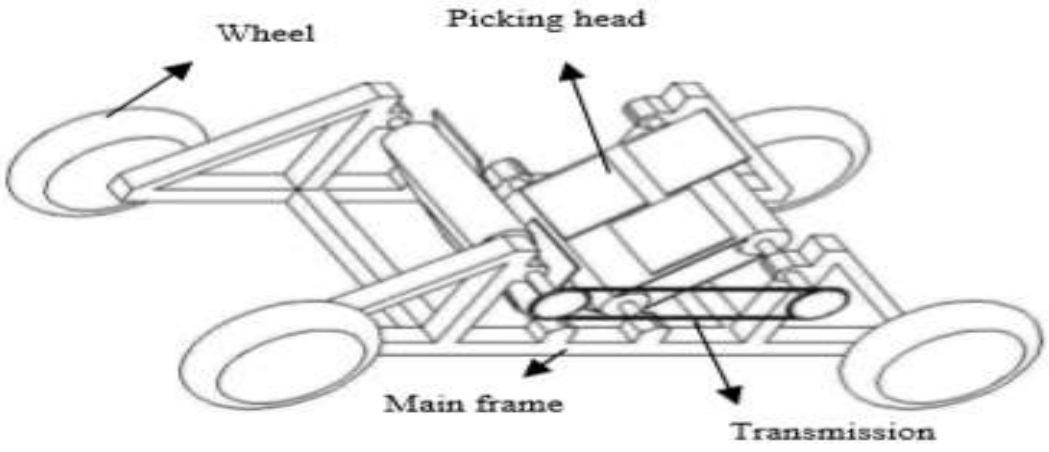

Figure 2. Manual saffron harvester

The height of the head can be set within 3-5 cm from land level. This machine has some advantages such as high performance and low losses in saffron harvesting as well as simple and cost-effective construction. However this prototype model also needs some modification as result of this examines evaluate success of this design about 60%. It means that 40% of products were treated.

Working of Mechanism

As shown in figure 13 the knives are installed on conveyors and are laid on conveyors except at two ends of conveyor where the knives contact with rollers. At these points when conveyors want to turn, the knives continue mowing on direct path while the pinned side of knives placed prepped to radius of roller. After this position the pinned side of knives began to turn over axis of rollers. This process is done at the same time on both conveyors. When the free end of knives contact each other, if any flower placed between them, act of knives picked up the flower. As early mentioned the front knives turn over the roller which its diameter is smaller than the other one. Then by equal linear velocity of conveyors, rotary speed of conveyor and knives over front roller would be greater, because V= Rω. Where=velocity speed R= radius of rotation ω= angular velocity İf R1≤R2 , R1 = 0.5 R2 Then: Because of: R1ω1 = R2ω2, ω1 = 2 ω2 Hence the front knife turn fast and for this reason the flower pushed to rear knife and after cutting, the flower laid on the rear knife. Finally the flower transported to the bin by the rear conveyor. Another saffron portable harvester was developed by Bertetto *et al.* (2006). It possesses a cam-strike system allowing to detach the goblet avoiding the foils damage (Figure 3). The harvesting device described is based on an operating principle quite different from the method used for the manual harvesting of Crocus Sativus L. flowers. The principle proposed has been easily mechanized in a cam striker mechanism. The device is an electric semi-automatic machine light enough to be a portable harvester. The cam's motor is supplied by a portable battery easy to use in field. As a result of tests, the device and the equipment appear to be suitable for mechanical harvesting and since almost 82% of the flowers were successfully picked in the field with an adequate number of cam's semi-oscillations up to 3.

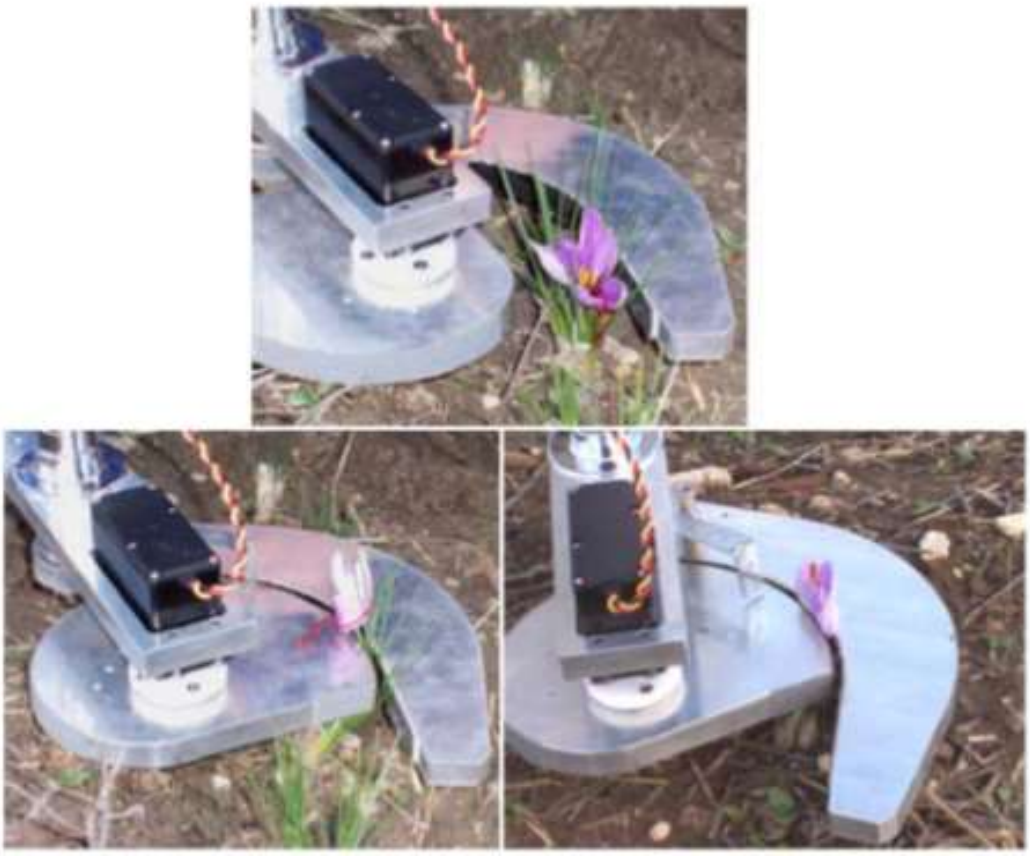

Figure 4. The Cam – strike harvesting device

Conclusions

The prototypes illustrated in this paper demonstrate their efficiency in experimental tests performed both in laboratory and on field. Experimental tests performed are useful to individuate the working parameters to obtain a dynamic sufficiently fast to perform an efficient detaching and harvesting strategy and a velocity flow field to perform an efficient and rapid cleaning process of the spice. Labor involved in saffron cultivation is excessive especially harvesting. In absence of mechanization there is lot of drudgery. If labor intensive unit operations are not mechanized, coming generations may not practice saffron cultivation. With steady increase in labor wages profitability and sustainability will get into jeopardy. The J & K state possesses a huge potentiality to adopt selective mechanization rather than sweeping mechanization. Presently the saffron harvesting is not highly mechanized and the farmers growing saffron face difficulties in timely completion of field operations due to lack of mechanization. It is rather excessive demanding mechanization through appropriate tools, implements and machines which not only reduce excessive labour but remove drudgery so that new generation continues to practice saffron cultivation in Kashmir region. The application of mechanization technology would increase saffron productivity. Consequently, labour tied up with manual farm operations would be released to higher value activities.

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