



Reviewed of Sesame Crop Harvesting in Sudan: Trials, Difficulties and Future Prospects

Elebaid J. Ibrahim* and Osama A. Muhieldeen

Department of Agricultural Engineering, Faculty of Agricultural Sciences,
University of Gezira- P.O. Box 20, Sudan.

*Corresponding author email: E-mail: ebaidjabir@gmail.com

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Abstract

The main target of this survey is to highlight the significance of sesame crop, production status, harvesting attempts previously tried and difficulties associated with the crop harvesting in the Sudan. Besides it is unlimited domestic benefits and various uses, the crop production has a direct influence on the livelihood and subsistence of small holder farmer's. Not only, but also it represents one of the most important oil seeds for hard currency earning. The crop is cultivated extensively on approximately more than three million feddans. However, different reports and statistics indicate that the crop exports and market prices fluctuating annually despite its global demand. These instable exports were due to the yearly variation in production which resulted from many problems encounters commercial production. Regardless of the agronomic and environmental factors, the strongest factors affecting sesame cultivation are high rate of harvesting cost and shortage of labor at harvest time. Farmers are permanently confronted with a state of panic and stress at harvesting due to critical harvest period and high and increasingly cutting cost. These problems result mainly from shattering varieties used, scarcity of labor and lack of appropriate harvesting machine. Accordingly, the area under the crop and productivity were remarkably declined over the last few years. Therefore, to increase crop productivity and quality and achieve stable production, a collective efforts of all stake holders and researchers are needed to develop high yielding widely adapted varieties with better disease resistance and convenient for machine applicability, particularly harvest operation.

Keywords: Manual harvesting, Mechanical harvesting, Sesame, Sudan.

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Introduction

Sesame (*sesame indicum L.*) is considered as one of the most pioneered crops known to man for oil extraction. It is one of the most traditional cash and export crops in the Sudan (Ahmed, 2013 ; Sabiel *et al.*, 2015). It is grown entirely under rain fed conditions and under the conventional and mechanized

systems. Sesame seed is extensively utilized as a source of human food, edible oil, feed to live stocks, various industrial and medicinal applications, in addition to its valuable use as crop rotation and intercropping (Renuka *et al.*, 2011; Sandipan *et al.*, 2010) . Besides the intensive and diverse local demand of this crop, it is largely cultivated under water

deficiency without any establishment inputs and well suited to several crops rotations (Ashri, 1998).

Sesame harvest begins when the seeds in the lower capsules ripe and most of the leaves become yellow and then brown or defoliate while pods are rather green in color (Elgaali, 2015). The ripening of pods begins from the lower stems bottom upward. At cutting time, most of the top capsules are likely half matured and the drying period permit seeds to ripen without losing (Weiss, 1983). The stalks may be cut below bottom capsules and then bound and stoked in the field for drying. With dehiscent cultivars, or when harvesting is delayed, it is preferred to cut the plants and dry them in bundles suspended downwards on racks for about two weeks. During this period, the seeds fall on mats located below the racks. Bundles shaking or beating with a stick may also be done for more seeds extraction. The non-shattering varieties may be mechanically harvested (Bedigian and Harlan, 1983). In some areas the bundles are left in the field, while in other places the bundles are put in a stocking enclosure (as in parts of Africa) or to a flat surface (as in parts of India) (Harlan, 1998). The crop mechanization level all over the world is very limited.

Sudan is regarded as an important country of the largest sesame producers worldwide (Banerjee and Kole, 2009). The country is classified as second in sesame export and the area under the crop is estimated by 80% and 40% of all Arabic countries and African continent, respectively (Elghali *et al.*, 1992). The crop ranking third in area cultivated and intercropped with sorghum and millet and considered as one of leading export crops (Abdalla and Abdel Nour, 2001). Most of sesame growing areas in Sudan are located between latitudes 10° and 15° from the Equator. The climate is characterized as semi-arid coupled with unpredictable rainfall ranging from 470 to 750 mm, usually occurs

from April to October (Khalid and Ali, 1988). The crop is grown mainly in the sandy soils of northern Kordofan and central clay plain, especially in Gedarif and Al-Damazin area. It is also sown in southern kordofan and southern Darfour and on small scale in the Southern region. The annual cultivated area was increased to 3.5 million feddans (1fed =0.42ha) for the 1990s (Khidir, 2003). Most of sesame fields are cultivated under conventional farming system with little or no use of machinery or modern inputs (Khalid and Ali, 1988). Numerous studies were conducted to increase crop productivity, but till now is low and not exceeds 100kg.fed⁻¹(MOAF, 2002). For the last decade the average yield was around 73 kg.fed⁻¹ (Khidir, 2003). Sudan is the one of the main eight exporting countries for sesame worldwide with more than half of its production is exported (FAO, 2012). The country rank second after India in cultivated area, despite that the country attained the lowest amount between the exporting countries. That is strongly attributed to the fluctuation in productivity levels due to the dependence on rain-fed production, and hence, consistently receive a lower price compared to adjacent Ethiopia (Glucroft *et al.*, 2012).

Sesame cultivation in the country constitute an essential source of subsistence and income generation for a considerable number of small scale farmers (Ahmed, 2008). However, Sudan sesame production for export confronted with several problems resulted in low productivity compared with other oilseed crops. Among them is the use of poor yield cultivars, traditional cultivation method, yield losses during threshing and inadequate use of agricultural inputs (Baydar, 2005; Iman *et al.*, 2011; Ogbonna & Ukaa, 2012). While other researchers attributed low productivity for low productivity varieties, pests and diseases, high rate of harvesting cost and lack of labor at harvest time (Mahmoud, 1994; Khidir, 1980).

Figure 1 showed the variability of sesame cultivated and harvested area and productivity per feddan for the last decade under the largest area for crop cultivation in the Sudan (Gedarif State, eastern Sudan). It is easy to observe the yearly variation in the three variables values. Whereas, the minimum cultivated and harvested areas depicted under this period were 474 and 366 thousand feddans respectively, with productivity a round 72.3 kg.fed^{-1} . In contrast, the highest levels obtained for cultivated and harvested areas were 1229 and 1118 thousand feddans while corresponding productivity was $327.6 \text{ kg.fed}^{-1}$. The variation in cultivated areas might be referred to rain instability, lack in drilling machines and farmers' economical situations, while disparity in harvested areas is virtually attributed to the deficiency of labor and absence of harvesting machines.

The crop productivity is extremely influenced by rain amount and distribution. However, the crop is very sensitive to water logging and weeds competition, particularly broad-leaf types, during early stages. Joshi (1985) reported that the suppression of weed competition at early crop establishment is essential, because the crop is weak and slowly developed at this stage. The regularity in rain amount and distribution in addition to weed control, results in well-crop establishment, which in turns lead to high yield per unit area. Figure 2 represents rain amount and distribution obtained from Gedarif Ministry of Agriculture and Forest during precipitation period. In fact, the real rainfall for the crop sowing is generally starts from June and increases gradually up to August which includes the highest value of fall amount and then decreases until completely stop in the early October as illustrated in the figure.

Sesame Harvesting

Several methods and techniques have been attempted for sesame harvesting in the Sudan

with different levels of success (El khidir, 1991; Mahmoud, 1979). These included manual cutting, partially mechanized and fully mechanized harvesting. The harvesting operation should be accomplished within a short time (about two weeks after physiological maturity). This is predetermined by the indeterminate plant growth habit, non- uniform maturity and especially seeds shattering during capsules drying. Yield diminution results from early harvesting, while delay (until the top capsules are ripe) lead to bottom pods opening and shattering of seeds (Osman, 1966). Were et al.(2006) Reported that harvesting of sesame plants when the capsules turned yellow gave the highest seed oil content (53.4%); further delay in harvesting resulted in seed loss by shattering without increase in oil content. On the contrary, harvesting at early stages reduced oil content. In Venezuela, Mazzani and Allieve (1966) studied the effects of different harvesting dates on yields of two varieties. They reported that there was a critical harvesting date in both varieties, whereas 39% yield reduction was obtained when the crop was cut three days earlier.

Hand harvesting of sesame

Sesame manual harvesting is the most arduous, laborious and time consuming operation which accounts for more than 70% of the total cost of crop production in the Sudan (Osman, 1966; Adil and Ahmed, 2015) In the northern and central parts of the country, the plants are usually cut with a small sickle below the lowest capsules. The plants are then bundled and placed in shocks. About two weeks later, bundles are shaken and sometimes are beaten for more seed extraction. Sometimes, sieving and winnowing are conducted for more cleaning and removing of any undesired particles. In the Southern Region of the Sudan (with heavier rainfall) plants are bundled after cutting and then hanged upside down to a rack with 3 to 5 meters height and about 5

meters long either in the field or around homestead. When Pods dry up, it opens and seeds fall on a carpet located beneath the stand and then beating complete threshing operation (Khidir, 1980).

During drying and threshing periods of sesame plants, seed loss occurs by means of shattering habit. Rheenen (1967) stated that losses from sesame dried in shocks or placed against racks were 8% to 9%, while Khidir (1980) mentioned that Khidir and El Hag using polythene sheets estimated about 12% losses between the time of cutting and threshing for crop dried in shocks. Rheenen (1967) investigated the possibility of improving hand harvesting practices through twelve harvesting methods. The methods were inspected and seed loss was found to be reduced from 8- 9% to less than 2% by threshing out of bundles after hanging them over fencelike frames where seeds were daily collected.

Mechanical harvesting of sesame

Mechanical harvesting of sesame became an urgent necessity in Sudan since hand harvesting is a troubling issue, cost incur with the increase of areas under the crop and the lack of labor and drinking water in the area of production (Abdalla, 1975; Ahmed, 1983). Actually, sesame cultivation in the country is a perilous project. The crop growers are usually confronted with a state of dread and disquiet at harvest time due to labor deficiency and due to loss of seeds by shattering because the time between physiological maturity and pods splitting is very short. This critical period give a rise to ever-increasing costs of crop cutting, bundling and threshing (Adil and Ahmed, 2015).

During the period of 1960-1990, several attempts with different methods for sesame harvesting were tried, which ranged from partially mechanized harvesting by using the binder and swather to fully mechanized

harvesting with combine harvester (Abdel Mageed, 1987; Dawelbeit, 1994). Different types of binders were tried in the country as an attempt for crop harvesting by cutting and binding the plants when most or all of their pods are still closed. Danish Seiga reaper binder (front tractor mounted) was tried during the decade of the 1950s and 1960s. Unfortunately, the machine performance resulted in some problems with the orientation of bundled plants and machine's knotting mechanism (Mahmoud, 1979). The performance of the machine was better with tall plants of an equal height compared with shorter ones. However, irregularity of plants growth was existed; whereas the short stalks fell to a recumbent position and blocked the path of those held upright before arrive to the knotting device. Moreover, the binder field capacity was quite low because it could cut and bind only 0.24% of the feddan per hour. By the beginning of 1970s, other binders of Yugoslav and another of Italian make were tried, but their performance was also unsatisfactory. Besides that, mowers were also examined but a little success was the result. The shortcoming of binders and mowers offered only partial solution for crop harvesting because the problem of hand operation was still needed for bundles collecting and threshing (Mahmoud, 1979).

Unsatisfactory performance of binders and mowers drew attention for focusing on using combine harvester. However, for combine harvesting of sesame, the whole plants and their capsules should be dry enough. So as to attain such level of dryness it requires waiting until approximately all pods are about to open and thus most of the seeds are expected to fall under shaking effect of the machine. Accordingly, fully mechanized harvesting had been attempted using a specially modified combine header for this purpose. Khidir and El Hag in season 1972/73 and 1973/1974 carried out some experiments

involving a combine with collecting trays head of the cutters. Due to the difficulty planting the experiments in well-defined rows it was not easy to precisely assess the value of seed losses. Therefore, The estimated seed loss was found to be 30% in the Sudan (Khidir, 1980); and according to Rheenen (1967) about 25% to 50% have been reported in Nigeria.

Mahmoud (1979) pointed out that a new approach was started in 1976 as cooperative program between Sudan/UNDP and University of California (Riverside). This program was executed basically as follows:

1. Spraying the plants with a Diquat such as Reglone at physiological maturity for desiccation.
2. Employing the cutting mechanism of combine harvester to cause vigorous shaking of plants before they actually cut. To minimize seed losses, the harvester collecting trays were fixed to the front of the cutting mechanism. This specially adapted combine was operated successfully in California and Mexico area on commercial scale. For the experimental plots conducted in the Sudan, the combine was satisfactorily operated with very little mechanical problems. The use of modified combine requires an attention into important preconditions. Row planting should be accurately spaced as the harvester cutter bars. Another difficulty was the affection of climatic conditions on desiccation components action, particularly atmospheric humidity. For sufficient desiccation, a relative humidity more than 30% at the spraying time was needed.

Imperial Chemical Industries (ICI) and CLASS carried out repeated trials in the Sudan for sesame crop in semi-broadcast pattern. Ogilvy (1979) stated that these attempts could be successfully harvested utilizing a relatively simple cutter bar attachment developed by CLASS Combines. The use of Reglone advanced harvesting date

by two to three weeks and resulted in clean seed and high oil content and seemed to delay natural dehiscence of pods. However, similar seed recovery from combine harvesting was obtained with or without pre-harvest desiccation by using Reglone. In both trials of 1977 and 1978, direct combining without desiccation was found to be the most cost-effective method, despite the significantly higher seed recovery in the hand harvested plots in 1978. Because of the high cost of Reglone treatment without any compensating increase in seed recovery, the net returns from hand harvesting and combining with desiccation were similar, in spite of the higher cost of hand harvesting. It seems that the mainly justification for using Reglone is to extend the harvesting season by advancing the start of harvesting in some parts of the crop area in very large schemes and its benefits such as cleanliness and high seed oil content are only marginal. The weed seed transferred to the subsequent crop looks likely to be less than with hand harvesting or combining an untreated crop.

In an experiment performed for three seasons in Sumsum National Center for the Development of Rain-fed Agriculture (SNCDRA), uneven losses were estimated during harvesting. No losses were obtained for manual cutting, while 8% and 9% harvesting losses were reported for swather and binder cutting, respectively, (SNCDRA, 1994). Although direct combine harvesting was more economical compared to other harvesting methods, but it resulted in high harvest losses ranged from 18.7% -26% (Mahmoud, 1994). The advantage of crop mechanized harvesting over manual harvesting is economically better, time and labor saving, particularly under expansion of areas and lack of labor. (El khidir, 1991; Mahmoud, 1979).

Conclusions

Due to the domestic use and economical returns of sesame cultivation in the Sudan, its production necessitates overcoming all production challenges and obstacles. Since sesame harvesting is the most difficult and time consuming operation due to scarcity of labor, shortage of drinking water, critical harvesting period and little use of harvesting machines, hand harvesting is an impossible practice direction. Thus, an effective mechanical harvesting manner and modern techniques are strongly recommended and virtually needed to find out a successful solution for sesame harvesting. Accordingly, it is an important to give attention to the following points aiming at the best harvesting solution:

- The need for cooperative and combined efforts of all levels i.e. from farmers, researchers, government and any other concerned with sesame crop production improvement in both directions quantity and quality.
- Development of high yielding sesame varieties with better disease resistance and suitable for harvest mechanization.
- Encouragement of sesame producers and any other stakeholder to adopt mechanized harvesting by providing convenient harvesting machines and keep them available at harvest time.
- An attention should be given by the government towards farmers' production by providing remunerative and stimulating prices of sesame as to induce them for increasing production.

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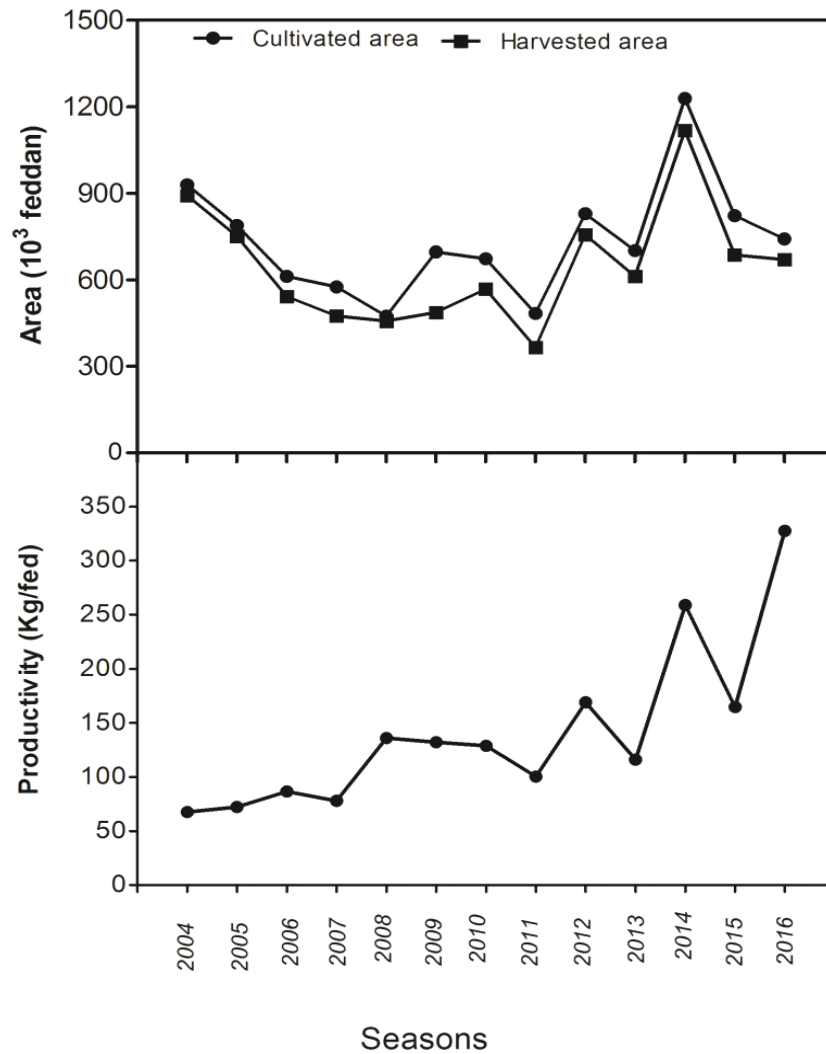


Fig.1: Variability of cultivated and harvested areas with their corresponding productivity for sesame crop cultivation under Gedarif state (the most productive area).

Source: Ministry of Agriculture and Forest, Gedarif State, Eastern Sudan, 2017.

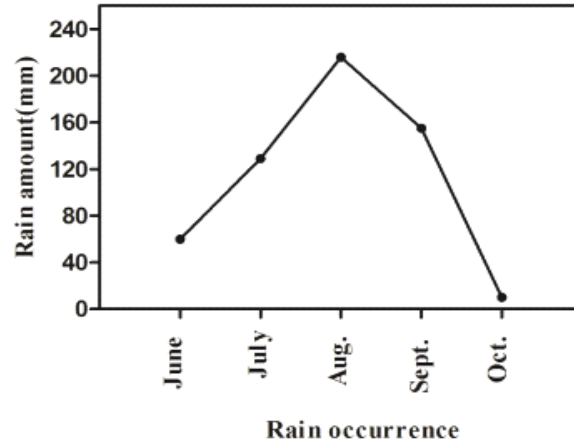


Fig.2. Rain fall amount and occurrence periods obtained during season 2009 from southern part of Gedarif state

Source: Ministry of Agriculture and Forest, Gedarif State, Eastern Sudan, 2011.

أستعراض حصاد السمسم في السودان: التجارب والصعوبات وآفاق المستقبل

العبيد جابر ابراهيم و أسامة عباس محي الدين

قسم الهندسة الزراعية، كلية العلوم الزراعية، جامعة الجزيرة، ود مدني ص. ب 0، السودان

المستخلص

الهدف الاساسى من هذه الدراسة هو القاء الضوء على أهمية حصول السمسم في السودان، حالة انتاجيته، والمحاولات العديدة التي أجريت لحصاده مصحوبة بالصعوبات التي تصاحبها بجانب ميزاته اللامحدودة وتنوع استخدامه محليا فان لانتاج المحصول تأثير مباشر على سبل العيش لكثير من اصحاب الحيازات الصغيرة ليس هذا فحسب بل يمثل الحصول واحدا من محاصيل النقد الاجنبى بالبلاد حيث يزرع بكثافة في مساحة لا تقل عن الثلاثة مليون فدان تشير بعض التقارير والأحصائيات الى ان كميات الصادر واسعارها في السوق العالمى تتغير سنويا رغم الطلب عليه عالمياً وقد يعزى هذا التغير للتباين السنوى فى الانتاجة التي تواجه بالعديد من المعوقات التي تحد من الانتاج التجارى بغض النظر عن العوامل النباتية والبيئية فان اقوى عوامل التأثير على استزراع المحصول هي ارتفاع معدل تكلفة الحصاد وقلة الايدى العاملة فى فترة الحصاد ففي هذه الفترة كثيراً ما يُصاب المزارع بحالة ان الذعر والضغط النفسى جراء التزايد المتسارع فى تكلفة قطع المحصول وذلك لقصر فترة حصاده التي تنذر بفقد الانتاج وتعود مشكلة حصاد السمسم فى المقام الاول لزراعة الأصناف التي تتفتح عند النضج النقص فى العمالة عند فترة الحصاد وعدم توفر الة مناسبة لحصاده بناءً على ما ذكر فان المساحة المزروعة وانتاجيتها قد تراجعت بصورة كبيرة خلال السنوات القليلة الماضية عليه فان زيادة الانتاجية ونوعية المنتج لتحقيق انتاج مستقر وعائد مجزٍ تتطلب من جميع اصحاب المصلحة من منتجين و باحثين واصحاب القرار أن تضافر الجهود لتطوير اصناف عالية الانتاجية مقاومة للأمراض جيدة التأقلم وملائمة للاستخدام الالى خصوصا عملية الحصاد .