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Review paper

Niger improvement and production in Ethiopia: progress and major challenges

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Niger crop is one of the under-utilized oil crops, but very crucial in Ethiopian diets and export system. Despite its importance, many problems have to be addressed through research. Starting from the beginning when a multidisciplinary approach of niger breeding started during the late 1960s century, some efforts have been made to overcome the major limitations of niger production and productivity in Ethiopia. However, there is a minimum application of modern breeding, and many challenges persist. The major challenges that face the niger breeding and production in Ethiopia are the nature of the crop (self-incompatibility), lodging and shattering, low yielding potential, susceptibility to pests, poor agronomic practices, less attention, and low inputs and modern farm technology. These challenges are retarding the breeding and also the production system of the niger. To make niger research more impactful on these challenges, exploiting and the use of novel research techniques which may include gene identification and transformation are very important. Moreover, genomic assisted breeding holds tremendous potential for improving productivity and provides better information for the breeding of niger. This review was provided with a brief explanation of the status of niger breeding and biotechnology aspects and the major challenges facing niger research and production in Ethiopia. Besides, the gap of research was forwarded in this document.

Key words: *nigerseed, breeding of nigerseed, biotechnology of nigerseed, self-incompatibility*

INTRODUCTION

Nigerseed, *Guizotia abyssinica* (L. f.) cass., Compositae, is one of the oil crops cultivated widely in Ethiopia and India. It is an indigenous, and under-utilized edible oil contributes to 50-60% of Ethiopian and 3% of Indian oil crop production (Getinet and Sharma, 1996). In Ethiopia, niger seed is the second oil crop in production next to linseed, accounting for a little more than one-fourth of total oilseed production (USDA and GAIN, 2020). It is a minor oil crop in some African countries like Uganda, Kenya, Sudan, and Malawi. Niger is relatively tolerant of the water-logging problem and more preferred to grow on poor drainage soils than other oil crops (Getinet & Sharma, 1996). The domestication of the niger was very ancient and may be originated in the highlands of Ethiopia. It was distributed to several parts of Africa, Asia, the USA, Germany, Switzerland, France, Canada, and Liechtenstein (Seegeler, 1983; Weiss, 1983; Getinet & Sharma, 1996). In the USA, niger seed is commonly referred to as thistle seed used as birds feed. Recently it was introduced to Thailand (Burnette, 2010). The production of the niger is highly emphasized in parts of Ethiopia and India. During the 2018 cropping season, from 0.785 million tons of total oilseeds production, about 0.3 million tons of niger seed produced, which is near to half of the total oil-seeds production in Ethiopia (CSA, 2018). In general, the production of oilseeds in Ethiopia is become increased from year to year. Niger seed has a great role in the human diet which can provide useful nutrition like protein. Its seed is useful to prepare 'wot' (cook) by mixing with crushed pulses in Ethiopia (Seegeler, 1983). Locally, the crushed seed is eaten alone or with bread and 'kolo', roasted pulses, or barley. Consumption of its oil also has a great role for human health containing phospholipids, tocopherols, and sterols substances which are very important to prevent diseases such as cancer and cardiovascular disorder (Ramadan and Morsel, 2002). It contains edible oil (40%), protein (20%), and composition of fatty acid such as linoleic acid (75-80%), palmitic and stearic acids (7-8%), and oleic acid (5-8%) (Dutta et al., 1994). Low acidity in the raw oil of nigerseed is preferable and its oil can be directly used for cooking. Besides, nigerseed is used as an input in most factories to produce different lubricants, soaps, and paints, (Getinet & Sharma, 1996). After oil extraction, its west product has rich in protein which is used for feeding animals and composting porpuses (Getinet & Sharma, 1996). It also has a relative potential to conserve and rehabilitate the farmland (Getinet & Sharma, 1996). Nigerseed is an indigenous and little-known crop (Ranganatha et al., 2016) with limited practices of modern research. Comprehensive research of the niger was started in 1979 after the establishment of a multidisciplinary team of the highland oilseed research program. The program considered the collection, characterization, and evaluation of germplasm. The existence of genetic and morphological variations has been exploited significantly, but because of the link between most traits, improving niger is relatively complicated. In addition, nigerseed is completely outcrossing species with self-incompatible. This nature is again challenging in niger improvement. Based on the outcrossing natures, breeders have been practiced population enhancement through mass selection and half-sib. As a result, few varieties were so far released in Ethiopia with some agronomic recommendations. Some molecular, and biotechnology studies were also relatively forwarded. However, niger breeding and production are overwhelmed with several challenges such are self-incompatibility, lodging and shattering, low yielding potential, susceptibility to pests, poor agronomic practices, less attention, and low input with farm technology. Therefore, researchers should focus on such challenges to improve the productivity of the niger in Ethiopia.

ORIGIN, DIVERSITY, AND DISTRIBUTION OF NIGER

Ethiopia is considered as the Centre of origin and/or diversity of several oil crops, such as nigerseed (*Guizotia abyssinica*), Ethiopian mustard (*Brassica carinata*), safflower (*Carthamus tinctorius*), linseed (*Linum usitatissimum*), and castor bean (*Ricinus communis*). Niger was native to the Ethiopian highlands, north of 10° N latitude (Baagøe, 1974). The archaeobotanical evidence suggests that the niger was domesticated in the pre-Aksumite period, even earlier than 3000 BC (Hiremath and Murthy, 1988). It may have originated from the wild species *Guizotia scabra* through a disruptive selection and cultivation by farmers over thousands of years (Belayneh, 1991; Hiremath and Murthy, 1992). The putative progenitor grows in Ethiopia, and Ethiopia considers as the Centre of origin for the niger (Murthy, 1996; Baagøe, 1974). Recently, Dempewolf et al. (2015) noted that the domestication of the niger was lacking. Some microsatellite analysis was done on the common garden of the niger to know whether the gene flow from the wild and/or the unfavorable associations have hindered the domestication of niger (Dempewolf et al., 2015). In this study, microsatellite analysis did not detect the recent admixtures between nigerseed and its wild progenitor, except for one population (Dempewolf et al., 2015). The hypotheses of poorly developed niger domestication are the high levels of phenotypic plasticity and outcrossing mating system due to self-incompatibility (Dempewolf et al., 2015). However, the majority of evidence like morphological, phytogeography, cytogenetic (Hiremath and Murthy, 1992; Murthy, 1996), and archaeobotanical (Hiremath and Murthy, 1988) evidence suggested that the domestication of niger in Ethiopia was very earlier than 3000 B.C (Baagøe, 1974; Getinet & Sharma, 1996; Murthy, 1996) and still cultivated as a principal oil crop in Ethiopia. Niger belongs to the *Guizotia* genus, Compositae family, Heliantheae tribe, and Coreopsidinae subtribe (Baagøe, 1974; Getinet and Sharma, 1996). According to the taxonomic revision presented by Baagøe (1974), the genus *Guizotia* has six species that include; (i) *Guizotia abyssinica* (L. f.) Cass., (ii) *Guizotia scabra* (Vis.) Chiov. subsp. scabra and subsp. schimperi (Sch. Bip.) Baagøe, (iii) *Guizotia zavattarii* Lanza (iv) *Guizotia arborescens* I. Friis. Hutch, (v) *Guizotia villosa* Sch. Bip., and (vi) *Guizotia reptans.* Later some taxon was added, and from these species, five of them, including *Guizotia abyssinica* are native to the highlands of Ethiopia (Baagøe, 1974; Getinet and Sharma, 1996). The genus *Guizotia* was distributed in several parts of Africa, particularly found largely in the highlands of Ethiopia. According to the previous report of Baagøe (1974), *Guizotia zavattarii* is endemic to southern Ethiopia (around Mount Mega) and the Huri hills in northern Kenya; *Guizotia arborescens* is also endemic to the south Ethiopia and Imantong mountain found on the border of Uganda and Sudan; *Guizotia villosa* is found in the northern and southern highlands of Ethiopia; *Guizotia scabra* is distributed from Ethiopia to Zimbabwe and Nigerian highlands. The only taxon which not reported from Ethiopia was *Guizotia reptans*, which is endemic to Kenyan Mount, the Aberdares, and Mount Elgonin East Africa (Baagøe, 1974; Dagne, 1994; Getinet and Sharma, 1996). Now a day the cultivation of niger was dispersed across several countries such as Africa (Sudan, Uganda, Zaire, Tanzania, Malawi, and Zimbabwe), Asia (Nepal, Bangladesh, and Bhutan), and the USA, France, Germany, Canada, Switzerland, and Liechtenstein (Baagøe, 1974; Seegeler, 1983; Weiss, 1983; Getinet and Sharma, 1996). Recently it was introduced to northern Thailand and started its research and production to some extent (Burnette, 2010).

PRODUCTION TRENDS OF NIGER IN ETHIOPIA

The nigerseed production was very ancient in Ethiopia. It is widely grown and contributes about 50% to 60% of oil crop production in Ethiopia. As the Central Statistics Agency (CSA) from about eighteen years of production trends indicated, niger seed production has been surprisingly increased from 1.04 million quintals to about 3 million quintals, which is two-fold of production increment (Figure 1). The productivity was also radically increased from about 0.35tha^{-1} to 1.14tha^{-1}. This production growth is not due to the area of expansion, because the production area was not changed according to the CSA report. This production growth may be due to the use of improved varieties and agronomic practices such as fertilizer, planting time, site selection, and field management. This may indicate an opportunity to enhance production and productivity through the development of suitable varieties and also agronomic practices.

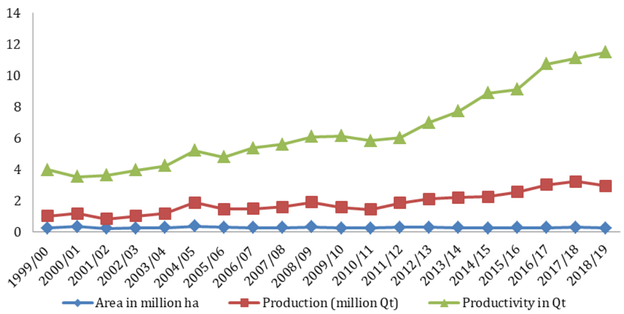

Figure 1. The production trends of niger seed in Ethiopia, from CSA data 1999 to 2018.

PROGRESS OF NIGER BREEDING

Historically, the research of oil crops in Ethiopia started earlier than the Italian invasion, with a few preliminary investigations, particularly on the nigerseed in Eritrea. A few Italian documents exist showing the work on niger landraces (Belayneh, 1991). The preliminary work on the collection and characterization of indigenous germplasms was initiated during the early 1940s. However, it was stopped for a few years until the early 1960s may be due to the conflict that occurred in the country. It again began during the 1960s at Debre Zeit and the then Alemaya University. Then from 1967 to 1974, the varietal development activities had continued at Holetta and Bako research center to develop high-yielding varieties with both seed yield and quality of oil contents (Getinet & Nigussie, 1991). However, a better organized and coordinated breeding work had started in 1979 after the establishment of a multidisciplinary team of highland oil crops (Getinet & Nigussie, 1991). This had further strengthened by the inception of the highland and lowland oil crop improvement projects financed by the International Development Research Center of Canada in 1991. These two projects were worked under an interdisciplinary team. Later the two projects joined together to form one project known as the Ethiopian Oilseed Improvement under the national coordinator of the Holotta Research Center (Getinet & Nigussie, 1991). The program was focused on the entire genetic resources to enhance seed yield and oil contents, and reduce shattering by performing collection, characterization and utilization of local landraces. The collection of niger, linseed, and Brassicas from Wello, Wellega, Gojam, Goder, and Shewa was done during 1981-1983 by jointly oil crop researchers and PGRC/E staff. A total of 1447 niger seed accessions was characterized at that period (Mekbib, 1991) and the Plant Genetic Resource Centre/Ethiopia (PGRC/E) preserved those collections, and utilized them by oil crop project in their breeding program (Getinet & Sharma, 1996). Ethiopian germplasm collection contains some desirable traits like short habit plants that could be used for the development of the dwarf type. However, the crop is highly outcrossing and self-incompatible, offers make trouble in the development of inbreeding lines and maintenance because of selfing is resulting in no or little seed setting. Breeders have practiced population enhancement through mass selection and sibbing techniques. Mass selection is one of the most powerful breeding methods used for improving the crop. As a result, several efforts had been made regarding variety development, and so far, five niger varieties were released in Ethiopia using conventional breeding (Table 1).

Table 1. Niger varieties are currently under production in Ethiopia (Tesfaye et al., 2016)

Variety name	Year of release	Maturity days	Oil content (%)	Seed yield (q/ha)	
				On Research field	On-farm field
Fogera	1988	147	39.6	9.00	3.97
Esete	1988	147	39.9	8.90	4.13
Kuyu	1994	145	38.0	10.90	-
Shambu	2002	140	38.5	9.50	5.60

PROGRESS OF NIGER BIOTECHNOLOGY

(i). Molecular Marker Technology Development

Molecular markers are offers play novel approaches to enhance conventional breeding which is used as a reference point to localize the genes of interest (Melchinger et al., 1991; Melchinger, 1993). The study of the molecular marker in niger seed breeding is relatively limited and very recent. Most of the studies are focused on the genetic diversity of the niger just to detect diversity among germplasms. Different molecular markers such as randomly amplified polymorphic DNA (RAPD) (Geleta et al., 2007; Nagella et al., 2008), amplified fragment length polymorphism (AFLP) (Geleta et al., 2008), inter simple sequence repeat (ISSR) (Petros et al., 2007) and EST-SSR (Misganaw & Abera, 2017) were applied mainly to detect niger genetic diversity. The first randomly amplified polymorphic DNA (RAPD) study was conducted on 70 representative populations of Ethiopian niger to reveal the genetic diversity of niger using RAPD (Geleta et al., 2007). The result indicated a highly polymorphic percentage of the markers were detected, and the loci showed 97% polymorphic for the whole materials used. For the individual population, the highest polymorphic was for the population from Wallo (66%) and the lowest was for the population from Gonder (37%), with a mean of 52% which suggests the existence of high genetic polymorphism in the niger population (Geleta et al., 2007). Another similar study was conducted on 18 niger cultivars from India to assess the genetic diversity using RAPD (Nagella et al., 2008). A total of eighty primers were used, and out of these, 17 primers that produced good and reproduced polymorphic bands (11% to 86%), with a mean of 41% were identified (Nagella et al., 2008). Amplified fragment length polymorphism (AFLP) analysis was also conducted on seventy niger seed populations collected from farmer's field of Ethiopia and 90% of polymorphism was observed (Geleta et al., 2008). This study further strengthened the previous studies of Geleta et al. (2007). Inter simple sequence repeat (ISSR) markers analysis was also done on 37 populations (accessions) collected from eight niger growing regions of Ethiopia and 89.83% of polymorphic DNA fragments were produced using five primers (Petros et al., 2007). Also, Hussain et al. (2015) used ISSR markers to estimate the genetic diversity amoung niger germplasms for oil parameters. They found the significant genetic and biochemical diversity among niger accessions and germplasms with the highest linoleic (>53%), palmitic acid (>9%), stearic acid (>8%), and least oleic acid (<29%) could be helpful in pre-breeding for hybridization to create a wide spectrum of variability in a subsequent segregating generation for various uses of fatty acid. Recently, EST-SSR markers were applied on 65 Ethiopian niger germplasms to trace the genetic diversity and evolutionary patterns at the molecular level (Misganaw & Abera, 2017). They concluded that the existence of considerable variations among niger genotypes which have a great advantage to obtain heterotic generation. Moreover, the establishment of genomic tools and resources for niger seed was done by Dempewolf et al. (2010). They identified 4 rRNA, 34 tRNAs sequences, and 80 coding sequences, including one region (trnH-psbA) with a 15% sequence divergence between niger and sunflower. These may be helpful, especially for phylogeographic studies in niger and its wild relatives. In general, the use of marker technology in niger crop breeding is relatively infant, and the application of modern breeding is limited. The construction of genetic maps is important for plant breeders to establish the association between markers and desirable phenotypic traits. Further research is needed regarding genetic mapping, high-throughput techniques (TILLING and EcoTILLING), and *Omics* tools (the use of genomic, transcriptomic, proteomic, metagenomics, and related techniques) provide useful information regarding response and adaptation of crop to abiotic stresses (Tadele, 2018). Also, the identification of interest genes which responsible for self-incompatibility and other biotic and abiotic-related stresses are very important and need further investigation.

(ii). Plant Tissue Culture

Plant tissue culture technology has a great role in crop improvement. It is needed in the genetic transformation and formation of somatic haploid embryos which are useful to generate homozygous (Mineo, 1990). Much plant regeneration through tissue culture has been developed for the niger through various researchers. It can be regenerated from the leaf (Sujatha, 1997; Baghel & Bansal, 2013; Jadimath et al., 1998), anther (Sarvesh et al., 1993; Adda et al., 1994; Murthy & Paek, 2000; Sarvesh et al., 1996), ovule (Bhat and Murthy, 2008), cotyledons and hypo-cotyledons (Nikam & Shitole, 1993; Ganapathi & Nataraja, 1993; Sujatha et al., 2009), and root (Nikam & Shitole, 1993; Nikam & Shitole, 1997) through in vitro culture. Sarvesh et al. (1993) reported the first regeneration from the anther of niger. Anther and microspore cultures are useful for the development of homozygous lines used for hybridization and crop improvement (Tiwari et al., 2011). Adda et al. (1994) also studied another culture for haploid production and developed the dwarfs, large flower head types, and self-compatible plants recovered which are useful for the niger improvement (Adda et al., 1994). Besides, Bhat and Murthy (2008) reported the haploid plants regenerated invitro from un-pollinated ovules of niger. Niger explants like root, hypocotyl, and cotyledonary were taken and cultured on Murashige and Skoog's basal medium (MS) containing BAP and kinetin (Nikam & Shitole, 1993). Multiple shoot regeneration induced from hypocotyl and cotyledonary explants, while root explants produced the only callus on MS medium supplemented with BAP, and 97% survival rate of the plantlets (Nikam & Shitole, 1993). The embryogenic suspension culture has great potential to aid the improvement and is suitable for in-vitro selection especially salt, cold, disease, and toxic tolerant lines in plants (Naik & Murthy, 2010; Tiwari et al., 2011). Protocols for niger regeneration had also been developed through tissue culture by different scholars at different times. Different concentrations of α-Naphthaleneacetic acid (NAA), IAA, and BAP were identified as the best formation of regeneration. For the callus induction and shoot formation of hypocotyls and cotyledons, the application of 0.5mgl^{-1} NAA in combination with 1mgl^{-1} BAP was found to be the best (Tesfaye et al., 2011). Sujatha (1997) studied a rapid and efficient method of in-vitro plant regeneration for large-scale propagation of male-sterile plants of niger. The medium with the application of 2.22 μM BA (N6-benzyl adenine) showed the best shoot regeneration in terms of frequency and number (Sujatha, 1997). Baghel and Bansal (2013) also evaluated the influence of BAP, Kn, and GA on in vitro regeneration and flower bud formation and the highest number and frequency of shoot regeneration observed from the MS medium supplemented with BAP (1mgl) (Baghel & Bansal, 2013).

(iii). Genetic Transformation

Genetic transformation is a technique applied in several crops which is the way of identifying and transferring the gene of interest into the desired genotype. No investigation has been made on the niger genetic transformation so far. Only Murthy et al. (2003) have been developed some protocols for genetic transformation through Agrobacterium-mediated in niger by using hypocotyl and cotyledon explants. They also found that cotyledon (15%) was better than hypocotyl (3%) explants for transformation (Table 2).

MAJOR CHALLENGES OF NIGER IMPROVEMENT AND PRODUCTION IN ETHIOPIA

Niger breeding and production are facing many challenges; most of the challenges are related to the nature of the crop that may have the potential to complicate its breeding. Of these challenges, self-incompatibility, lodging and shattering, low seed yield potential, less focus, poor agronomic practices, and lack of modern inputs are the major challenges facing the breeding and production aspect of niger in Ethiopia.

(i). Self-Incompatibility (SI)

Self-incompatibility (SI) is the mechanism used to prevent inbreeding and refers to the inability of self-fertilization, in which the stigma failed to receive the pollen of the same

Table 2. Summary of in vitro regeneration from different parts of the niger plant

Explants	Processes	Growth regulatory/media	References
Anther	Induction of embryogenic and non-embryogenic callus	Chaleff's R-2 and MS basal media	(Adda et al., 1994; Sarvesh et al., 1996)
Anther and bud	Induction of embryogenesis and plant regeneration	2,4-D alone and	(Murthy et al., 2000)
Flower buds and un-pollinated ovule	Induction of gynogenesis	2,4-D either alone or combination of adenine, BA, 2iP, and kinetin	(Bhat & Murthy, 2007)
Un-pollinated ovules	Plant regeneration	NAA + kinetin	(Bhat & Murthy, 2008)
Leaf segment	Somatic embryogenesis	2,4-D and	(Kumar et al., 2000; Jadimath et al., 1998)
	Plant regeneration	BAP, Kn and GA	(Baghel & Bansal, 2013)
	Plant regeneration	BA and kinetin individually and in combination with IBA and NAA	(Sujatha, 1997)
Root, hypocotyl, and cotyledonary	Plant regeneration	BAP and kinetin	(Nikam & Shitole, 1993)
Root, hypocotyl, and cotyledon	Callus induction	IAA + BAP	(Nikam & Shitole, 1997)
Cotyledonary leaves	Somatic embryogenesis	2,4-D and kinetin	(Naik & Murthy, 2010)
Hypocotyl and cotyledonary leaf	Plant regeneration	Auxins (IAA, NAA, IBA or 2,4-D) and Cytokinins (KN or BA)	(Ganapathi & Nataraja, 1993; Sujatha et al., 2009)
Apical and axillary buds, leaf and internode	Plant regeneration	Different concentrations of Thidiazuron promoters	(Baghel & Bansal, 2014)

flower and hence did not produce seed. It is the most widespread in adaptation to outcrossing in flowering plants. Self-incompatibility system is classified as heteromorphic and homomorphic (Acquaah, 2009). Homomorphic self-incompatibility is further classified as gametophytic and sporophytic (Acquaah, 2009). Sporophytic self-incompatibility is the characteristics of pollen that are determined by the plant (sporophyte) that produces it and is more visible in species like broccoli, raddish, and kale. the mechanisms involved in cross-pollinated. Niger is strictly self-incompatible and is under the direct influence of the sporophytic self-incompatible system (Nemomissa et al., 1999; Geleta and Bryngelsson, 2010). The sporophytic SI system is the most complex breeding system of plants because of the presence of many crossing possibilities and the interaction of S-alleles. This nature of the crop complicates the breeding system in the development of a pure line of niger. However, some interesting attempts have been made to develop the compatibility of the niger population (Geleta and Bryngelsson, 2010). Some degrees of self-compatibility were observed in the Ethiopian gene pool for the first time. This doesn't mean that such plants are truly self-compatible because the SI may occur in the next generations. Such character is known as pseudo-self-incompatibility (Nemomissa et al., 1999). Additionally, they also reported the F1 hybrid of the two self-compatible lines outperformed both parental lines in terms of yield and yield-related traits, suggesting hybrid vigor. This is another interesting result helpful for setting a new strategy for hybrid development once sufficient self-compatible lines have been developed.

(ii). Lodging and shattering problems

The problems of lodging and shattering are the most important seed yield limiting-factors widely observed in niger production. Lodging is a serious problem, especially in the late-maturing and tall varieties of niger. The varieties which have an early maturing period and shorter height can relatively minimize the problem caused by lodging to some extent. So, these traits are desirable traits that are usable in the breeding system. Similarly, the seed shattering problem is also common in the nigerseed production because the niger is un-determinate maturity that continues its vegetative growth even when the seed goes to maturity. This makes it difficult to identify the exact period of maturity, and a serious shattering can be encountered. Such challenges have the potential to hinder production, and productivity, and should be improved through systematic breeding.

(iii). Low seed yield potential

Niger seed is extremely low in yield, which is about 800 to 1000 kg ha^{-1} even under optimum growing conditions. Low seed yield may be related to the low efficiency of photosynthesis of the crop and other yield-limiting factors. There is a meager scientific background on the niger plant architecture towards photosynthetic efficiency to improve sink capacity, which may useful for the increment of yield potential. Although one of the primary objectives of breeding was increasing seed yield and oil contents, few varieties have been developed relatively with some yield increment. This is not enough, and further investigations are needed to enhance the seed yield, non-shattering, fertilizer responsiveness, high harvest index, and desirable maturity of the crop.

(iv). Susceptibility to pests

The production and productivity of nigerseed are affected by many pests. Although the niger is considered to have fewer diseases than other oilseeds (Getinet and Sharma, 1996), however diseases such as stem and leaf blight, leaf spot, powdery mildew, and other seed-borne diseases are identified as the most important diseases of nigerseed and cause yield reduction. In the case of insect pests, the flower of the niger is attacked by an insect such as a niger fly and black pollen beetles, which could feed its flower and interfere with pollination causing a severe reduction of seed set. Moreover, parasitic weed infestation, particularly Dodder and Orobanche could also cause a serious yield reduction of nigerseed (Getinet and Sharma, 1996). Even it may cause a total yield loss when infested early and 45 days after the emergency (Getinet and Sharma, 1996).

(v). Low inputs and farm technology

The limitation of modern input is the problem of the Ethiopian agricultural system as a whole. Particularly, for the nigerseed production, there is no or less use of modern inputs starting from the supply (low quality and insufficient seed, fertilizer, chemicals) to mechanization. Farmers used low input; even they do not use fertilizer in some cases for nigerseed. So, sometimes oil crop production in Ethiopia is considered as near organic standards (Wijnands et al., 2007). However, this low input has the potential of retarding oil crop production. Also, insufficient quality seed is one of the major challenges observed in the country (Sisay et al., 2017). On the other hand, production is not supported by mechanization. Agricultural mechanization in Africa is at the infant stage, which is the involvement of animate power (human muscles or draft animals) with some mechanical power used to perform energy-intensive tasks (FAO and AUC, 2018). Particularly, in Ethiopia, the application of hand-tool technology is common, and it depends almost on human muscle power for about 60-80% of cultivated land. So to commercialize the production, modern farm technology (mechanization) is a must, so the emphasis should be necessary for this area.

(vi). Poor agronomic packages

Poor agronomic practices are also limiting the yield of crops. The gap of research is highly observed regarding the physiological aspects of the niger crop. Some efforts have been developed on the agronomic recommendations such as fertilizer rate, seed rate, and planting time to increase the production. But not enough and more efforts are also needed to develop full agronomic packages that consider the aspects of the crop water use efficiency, soil nutrition and soil conservation, desirable architecture, and other abiotic stresses. These agronomic aspects are directly contributing to maximum production and productivity.

(vii). Less attention

The major crops that are grown in Ethiopia are cereals and legumes. Thus agricultural research for the development of improved varieties, seed production, and other supplements is focused on these crops. Sufficient attention and support from government and private are not as satisfying the niger research. Additionally, niger is a neglected and under-utilized crop (Getinet & Sharma, 1996), so it has no or little support and consideration from international projects and organizations. Moreover, the niger is a highly demanded oilseed since it is chosen for export earnings, and its refined edible oil is essential for Ethiopian development strategy to increase the availability of national edible oil on the local markets (Lefebvre, 2012). And several oil factories are established in different areas of the country, and they highly need raw materials like niger seed. So the demand is not a problem. The problem is the insufficient availability of improved materials with better oil and seed yield varieties. Therefore, giving attention to the research areas to increase the seed yield and thereby fill the gap of demand is important.

CONCLUSION

Niger is a vital crop for nutrition, human health, and economic aspect of Ethiopia. As far as utilizing the indigenous germplasms, some efforts have been made to develop better oil quality and high seed yield of niger cultivars, however, some unresolved challenges such as self-incompatibility, lodging and shattering, low yielding potential, poor agronomic packages, pests problem, lack of inputs and farm technology, and low focus are facing the breeding and production of niger in the country. Focusing on these challenges and developing a breeding strategy that includes modern research is a very important approach. There is no doubt that the breeding of niger should be supported by advanced molecular tools. However, a lack of comprehensive research, particularly on genetic mapping, high-throughput approaches, omics tools (genomic, transcriptomic, proteomic, metagenomics, and related techniques), genetic transformation, and QTL mapping is the major gap. Additionally, research on a physiological aspect of the crop is also needed to improve agronomic activities. Furthermore, the effort made to develop self-compatible materials is very interesting and should be further strengthened; once the self-compatible genotypes developed the breeding complexity may be solved.

COMPETING INTERESTS

The author declares that I have no conflict of interest.

ETHICS APPROVAL

Not applicable.

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