Original Article: Prevalence and socio-economic impact of Striga (*Striga hermonthica*) in sorghum producing areas of east and west Hararghe zones, Ethiopia

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ABSTRACT

The field survey focused on potential sorghum-producing east and west Hararghe zones in six districts comprising 18 villages in the 2019 cropping season. Overall, 720 growers were nominated for considering the socio-economic impact. The representative growers were purposively selected. Data collected were Striga counts per m^2 and per plant, time of Striga introduction, awareness and impression of farmers, prevalence, management used, severity, and collective actions to manage Striga. Both genders were included. Data were collected from interviews and analyzed. Statistical software (SPSS) summarizes the information. Results showed two Striga species, *Striga hermonthica* and *Striga asiatica* were observed and recorded. *Striga hermonthica* is more distributed than *Striga asiatica* in all the study locations and its occurrence diverse between locations. The maximum levels of Striga occurrence was perceived at Kile-besidimo (92%), Edobaso (85%), Kufakas (82%), Kotora (80%), Homacho Riana(78%), Bal'ina arba (74%), Dire gudina (72%), Bishan babile,(66%), Qufa (65%), Oda Anesso (48%), Ijakechu (45%), Umer kulle (40%), Homacho Eba (38%) and Tofik (35%). In contradict less number of *Striga* prevalence was perceived at Bareda (29%), Haro Adii (27%), Jiru gemachu (25%), and Homacho dayo (23%) striga per m2 in assessed fields. The striga count per plant was also recorded from each site. Sorghum yield loss due to Striga across surveyed villages was estimated to range between 0% and 80%. The management practices focused on improving the shortages suggested for controlling Striga in the districts.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is produced in the semiarid areas where crop production is hard due to unfertile soil. It is adapted to diverse environmental changes and a vital crop to foods of poor people where drought causes regular failures of other crops in the semi-arid tropics (Godbharle et al. 2010). Globally sorghum is 5th significant cereal crop after maize, wheat and barley production (Kumar et al. 2011, Mushtaq et al. 2019). Generally, sorghum is grown in marginal areas with high temperature and low rainfall under dryland conditions (Mabhaudhi et al. 2019). The sorghum is frequently produced by smallholder growers (Wortmann et al. 2009), using low inputs (Haji and Tegegne, 2018), on degraded soils (Smale et al. 2018). It can succeed under harsh environmental conditions (Kante et al. 2019). It is the third major cereal crop in Ethiopia and is cultivated in extreme drought areas of the country. It is well-known for its adaptability, diversity and is cultivated over different agro-ecological areas (Demeke and Di Marcantonio, 2013; CSA, 2019).

Sorghum is largely grown as a diets crop in the semi-arid and arid tropics of Asia and Africa; whereas in the industrialized countries the crop is used for livestock feed (Rakshit et al. 2014). The sorghum grain is chosen next to teff for the preparation of bread. It is one of the main significant crops produced as food insurance in the eastern, northern, and northeastern lowland areas of Ethiopia, where the climate is categorized by inconsistent rainfall and drought (Degu et al. 2009). The sorghum productivity is 2.3 ton/hectors below its potential due to edaphic and biotic factors affecting sorghum production in Ethiopia (Belay, 2018). The primary limitations cause for this less productivity are pests, low soil fertility and drought. Among the pests, parasitic weed (Striga) is the main biotic factor in the production of sorghum in Ethiopia.

Striga is supposed to be originated around the border of Ethiopia and Sudan (Nubia) where it causes high yield losses in all cereal crops. Although striga is a common in Africa it inhibited sorghum production globally (Parker and Riches, 1993). The sorghum yield loss due to Striga alone was estimated at US $7 billion in sub-Saharan Africa, and the Ethiopia share was $75 million annually (Badu-Apraku and Akinwale, 2011). In many countries Striga infestation has expanded with a resulting decline in food production (Fasil, 2002). The losses attributed to Striga weed range between (30-100%) in most areas (Gebisa and Gressel, 2007) and are often aggravated by low soil fertility. Striga produces allelopathic chemicals (toxins) that interfere with other crop species. Striga invades the susceptible host while increasing the Striga soil seed bank and crop exudates makes to stimulate striga seeds germination and ever-increasing the reduction of yields (Okonkwo, 2006). Around three hundred million people in sub-Saharan Africa harmfully affected due to high striga infestation in a million hectares of land (Ejeta, 2007). Crop yield losses between 65 and 100 percent due to Striga are common in heavily infested fields in the cereal production in Ethiopia (Ejeta et al. 2002; Fasil et al. 2010).

A single Striga plant can produce above one hundred thousand seeds. This makes its control too difficult. The great number of seeds will be returned to the soil increasing the seed bank if Striga plants are allowed to flower and seed. The problem of Striga is related with the cropping system, which contributes to reducing soil fertility and increasing the soil seed bank of Striga. Striga has remained a severe problem, attacking finger millet, sorghum, and maize in the northern parts of Ethiopia (Rebka et al. 2014; Mesfin, 2016). Striga has been recorded in more than 40 countries. In Ethiopia, Striga is the main biotic limitation and a severe menace to subsistence food production (Ejeta, 2007). In eastern Ethiopia the farming systems consist of different production units including a variety of inter-dependent mixed cropping activities. The major crops produced on a large scale to improve food security in Hararghe include sorghum, maize, sweet potato and groundnut. Other crops include wheat, teff, legumes, onions, shallots, cabbage and vegetables produced on a small scale. Chat and coffee have well-known and broadly cultivated as cash crops. Climate changes with pest infestations and crop diseases are furthermore hindering crop production in Hararghe. The main sorghum production challenges in this area are drought, less soil fertility and mono-cropping. Striga is the main challenge among pests to sorghum production in eastern Ethiopia (Zerihun, 2016).

However, the knowledge of Striga prevalence, distribution, and socio-economic constraints on sorghum production in the east and west Hararghe zones, were not assessed and documented. Such information suggested interventions that may help create awareness between the agricultural community and improve good agronomic practices for Striga management that have not been specified insufficient research attention. Thus, the objective of this study was concerned with the prevalence and socio-economic influence of Striga infestation in sorghum growing areas of east and west Hararghe Zones.

Materials and Methods

Description of the Surveyed Area

A Survey field was conducted from mid-September to November 2019 in the East and West Hararghe zones. The East Hararghe Zones is located at GPS coordinates of 8° 48' 28.9008" N and 41° 36' 4.2516" E. and West Hararghe zone is located at a latitude of 8° 39' 59.99" N and longitude of 40° 29' 59.99" E. through the lowest elevation at 1002m and the highest at 3414m above sea level. Six districts namely, Bible, Fedis, Kurfachalle, Gemechis, Habro, and Darolabu selected due to high Striga infestation and the major sorghum-producing areas in the zones. The agro-climatic condition includes lowland (40%), midland (45%), and the highland regions (15%).

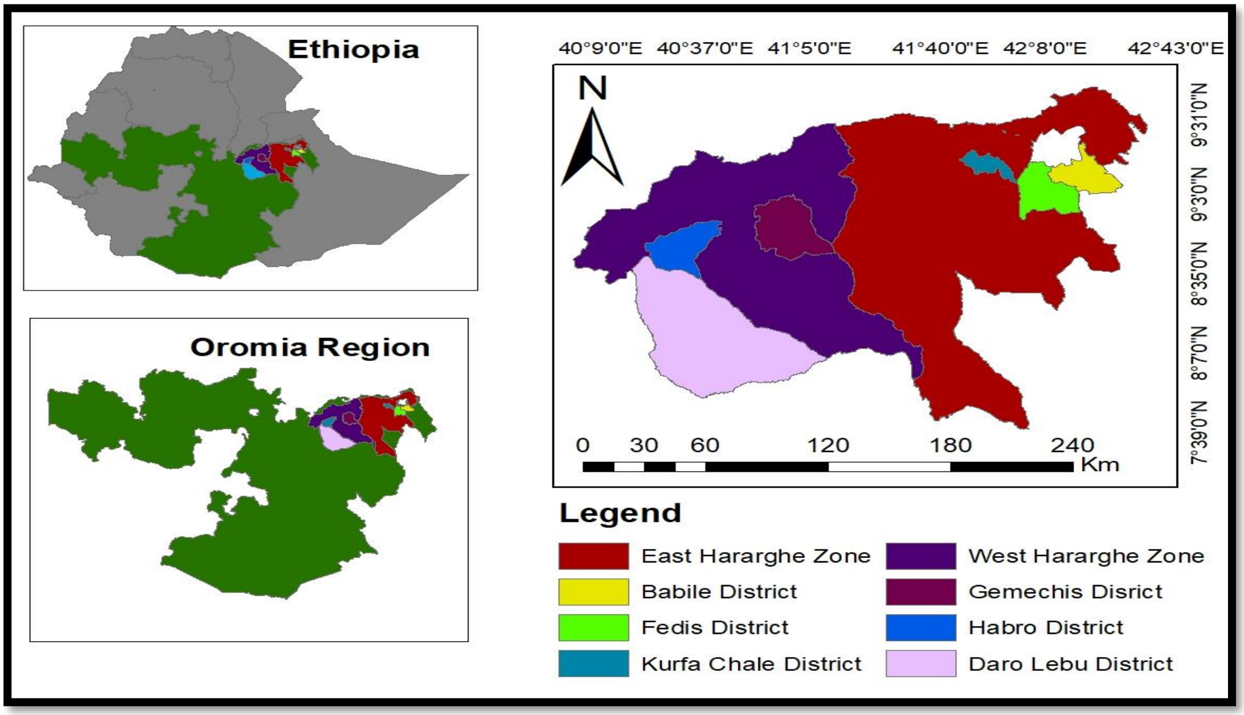

Figure 1. Map of the surveyed districts in 2019 cropping season.

The averages rainfall ranges from below 710mm for the lowland area to nearly 1150mm for the highland areas annually. The erraticism of rainfall from time to time and its often-irregular distribution throughout the cultivation periods provide a wide range of climatic vulnerabilities that challenges farmers.

Field Survey

A survey of Striga prevalence was conducted by traveling with vehicles along all accessible roads across six districts in both Zones. The sample points were at every 2km intervals and the purposive sampling method was used by1m x 1m quadrants in a zigzag manner and 50 fields per district and 15 sampling points per field were taken. The abundance of Striga at each sample point was determined by calculating the number of fields infested divided by the total number of fields observed and described in percentage (Abbes et al. 2007). Prevalence %=Number of Striga field infested x 100/total number of fields observed.

Striga occurrences were estimated using a 0 to 100% scale. On this scale, 0% represents a field in which no Striga had emerged and 100% represented a field in which all the host plants carried emerged Striga (Mokhtar et al. 2009). The relative abundance/occurrence level scoring rates used was: 0-5% = Rare, 5-15%=Occasional; 15-30%=Present; 30-50%=Frequent; 50-75%= Abundant; 75-100%=Very abundant. The relative rating percentages used in these scoring schemes are indicators of relative coverage of the targeted Striga on the land they were found compared to the local vegetation in the respective sample points.

The yield loss was determined based on emerged striga number per sorghum plant. Yield loss on farmers‟ fields was estimated following the method of Mesa Garcia and Garcia Torres (1984) as follows: L = 100 x 0.124 x SN, L= percent yield loss; SN= emerged Striga number per plant.

Assessment of Socio-Economic Impact

The socio-economic assessment was covered the major sorghum producing area of the east and west Hararghe zones in six districts mainly the villages of Homacho Riana, Homacho Dayo, Homacho Eba, Kufakas, Qufa, Barreda, Oda Anesso, Kotora, Haro Adii, Kile-besidimo, Bishan Bible, Tofik, Edobaso, Umerkulle, Bal'ina arba, Dire gudina, Ijakechu and Jiru gemachu. Seven hundred twenty (720) growers were nominated for the formal survey of assessing the socio-economic impact of Striga from all districts and one hundred twenty (120) growers were nominated from each district (Table1). Purposive samplings were used to select the representative farmers from the list of farmers in the community. The respondent farmers were categorized into three strata. The first strata consist of farmers from high Striga infested areas while the second strata consist of farmers from medium Striga infested areas and the third stratum were the farmers from non-striga infested areas. Forty farmers were selected from each stratum. Both men and women were interviewed to get the required information from each respondent's stratum and women accounted for 21% of the total sample size.

Table 1. Sample size in the Striga focus areas of East and West Hararghe Zones.

Respondent category	Men		Women		Overall sample	
	N	%	N	%	N	%
High infestation	30	80	10	20	40	100
Medium infestation	28	78	12	22	40	100
No infestation	26	78	14	22	40	100
Total	84	79	36	21	120	100

N: sample size per district.

Data collected

Time of introduction of Striga in the area, the trend of the problem, awareness, and impression of farmers, the abundance of the Striga in the area, dispersal mechanisms of Striga, the effect of Striga on crop plants, sorghum production constraints, control methods used by communities to manage Striga, other advantages and disadvantages of Striga and willingness of the community for collective actions to manage or prevent Striga.

Data Analysis

The questionnaire was coded and the data entered into a computer for analysis. Statistical software (SPSS) and excel were used to summarize the information and analyze the data. A universal approach had been followed to come up with intervention measures that take the entire social, economic, institutional, and agro-ecological environment of the communities into account.

Results and Discussion

The result showed that two Striga species observed (*Striga hermonthica* and *Striga asiatica*) were observed and recorded. But *Striga hermonthica* was the most prevalent in all the districts compared to *Striga asiatica* (Table 2). For this reason, this survey was only focused on *Striga hermonthica*. *Striga hermonthica* expands most on sorghum fields. This was observing and the response obtained by the household respondents. The outcome of this study was in agreement with the research conducted by Mesfin (2016) in Ethiopia which revealed that only *Striga hermonthica* causes economic losses in sorghum.

In general, *Striga hermonthica* was extremely distributed and affecting sorghum production. But, the infestation level of *Striga hermonthica* varies among sites. Consequently, the large number of Striga in most sites was recorded relatively. In another way, some locations have a moderate infestation and low Striga infestation levels per square meter. Among the surveyed villages (Kile-besidimo (92%), Edobaso (85%), Kufakas (82%), Kotora (80), Homacho Riana (78%), Bal'ina arba (74%), Dire gudina (72%)) farmers' fields were the most affected one in the area. The prevalence result (Table 2) shows that percentage of prevalence and average infestation of Striga level per meter square.

Table 2. Prevalence and average of *Striga hermonthica* infestation per m^2 in six districts of East and West Hararghe Zone 2019 cropping season.

Districts	Villages	No. of fields observed	Prevalence%	Average of striga infestation/M^2		Abundance level scoring rates
				Range	Mean	
Babile	Besidimo	20	92	75-100	85	Very abundant
	Tofik	15	35	30-50	31	Frequent
	Bishan babile	15	66	50-75	54	Abundant
Fedis	Edobaso	20	85	75-100	78	Very abundant
	Bal'ina arba	15	74	50-75	55	Abundant
	Umer kulle	15	40	30-50	32	Frequent
Kurfachale	Dire gudina	20	72	50-75	53	Abundant
	Ijakechu	18	45	30-50	35	Frequent
	Jiru gemachu	12	25	30-50	16	Present
Gemachis	H/Riana	20	78	75-100	66	Very abundant
	H/Dayo	15	23	15-30	15	Present
	H/Eba	15	38	30-50	30	Frequent
Habro	Kufakas	20	82	75-100	77	Very abundant
	Qufa	15	65	30-50	43	Abundant
	Bareda	15	29	15-30	20	Present
Darolabu	Oda Anesso	15	48	30-50	39	Frequent
	Kotora	20	80	75-100	76	Very abundant
	Haro Adi	15	27	15-30	18	Present

Table shows the highest Striga infestation was observed at Kile-besidimo (92%), Edobaso (85%), Kufakas (82%), Kotora (80%), Homacho Riana (78%), Bal'ina arba (74%), Dire gudina (72%) and medium infestation Bishan Babile,(66%), Qufa(65%), Oda Anesso (48%), Ijakechu (45%), Umer kulle (40%), Homacho Eba (38%) Tofik (35%) in each district. In opposite to this, the small number of Striga infestation was perceived at Bareda (29%), H/Adii (27%), Jiru gemachu (25%), and Homacho dayo (23%) Striga per m^2 in assessed fields.

Population of Striga in Farmers Field

The highest Striga count per plants was recorded from Kile-besidimo (6 Striga/plants) followed by, Edobaso (6 Striga/plants), Kufakas (6 Striga/plants), Kotora (5 Striga/plants), H/Riana (5 Striga/plants), Bal'ina arba (5 Striga/plants), Dire gudina (5 Striga/plants), Bishan babile,(4 Striga/plants), Qufa (4 Striga/plants), Oda Anesso (4 Striga/plants), Umer kulle (4 Striga/plants), Ijakechu (3 Striga/plants), Homacho Eba (2 Striga/plants) and Tofik (2 Striga/plants) villages that had estimated high yield losses of 31% to 80%. Whereas, less number of Striga was recorded from Bareda (2), H/Adii (2), Jiru gemachu (1), Homacho dayo (1) and the lowest estimated mean yield loss ranged from 0% to 30%.

Assessment of Socio-Economic Impact

Yield loss of sorghum due to *Striga hermonthica* across surveyed villages was estimated to range between 0% and 80%. The mean estimated yield loss across farmers' fields among villages varied depending on the intensity of infestation (Figure 2). This result in agreement with Ejeta et al. (2002) indicated that yield losses of 65 up to 100% in Sudan and Ethiopia which are common in the severely damaged field but the total loss could occur when Striga attack is compounded by drought. Yield losses caused by Striga are often significant and infestation by Striga usually results in substantial yield reduction often surpassing 65% in heavily infested fields. As indicated by Haussmann et al. (2000) crop yield losses up to 100 percent are possible on susceptible sorghum varieties under more Striga infestation.

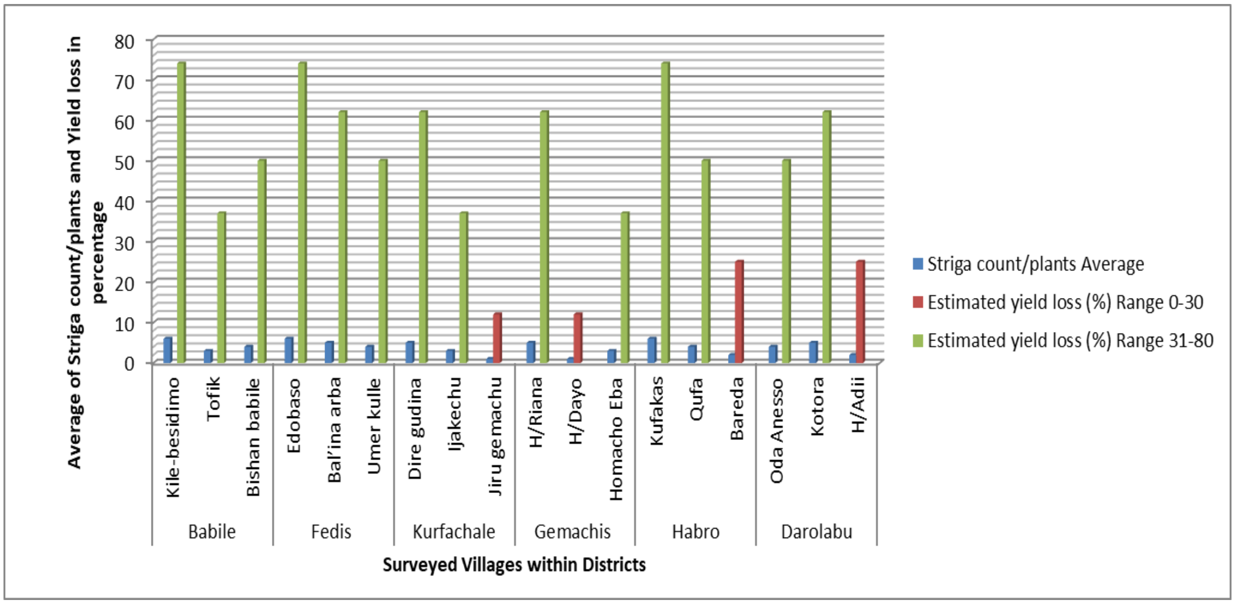

Figure 2. Assessment of estimated sorghum yield loss following the method of Mesa Garcia and Garcia Torres (1984).

Demographic Characteristics of the Respondents

During the survey period, men largely participated in farming activity than women in the selected area (Figure 3). Accordingly, enough information obtained related to their farm activities and provide adequate information about Striga problems for this study (Table 3).

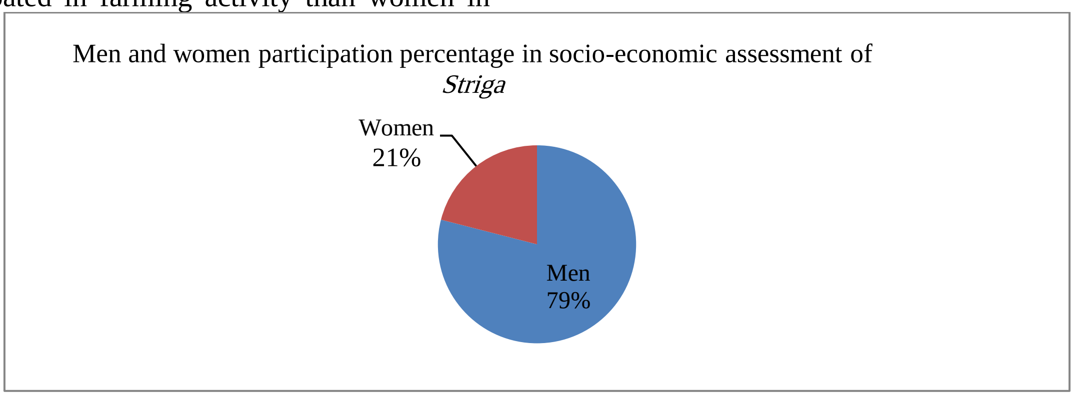

Figure 3. Gender ratio of the producer respondents in socio-economic assessment of *Striga*.

Farmers' Responses on Source of Striga Introduction

According to farmer household respondents shown that in 40% of the farmers' farm fields Striga occurs for more than 20 years. This indicates that the farm communities are unable to eliminate this noxious parasitic weed from their farm field, so that Striga continues for a long period on their farm field. This implies Striga distribution has increased from time to time. Based on farmers' response before thirty years the surveyed area was rich in fertile soil and growers did not apply artificial fertilizers. Currently the status of soil decreased due to the absence of crop rotation and soil erosion. As a consequence, the farmers' farm fields became unproductive without chemical fertilizers, the number of populations increased from time to time, the farmland reduced and there was no fallow period, more mono-cropping and a few intercropping was practiced in the study area.

The majority of the farmers said the source of *Striga* introduction on their farmland was from the surrounding area, others said from abroad and some of the farmers do not know the source of Striga introduction into farm fields (Table 3).

Table 3. Perception of farmers on the source of *Striga* introduction in each District.

Zone	District	Village	N	Source of introduction		
				Surrounding Areas	Abroad	Unknown
W/Hararghe	Gemachis	H/Riana	40	30	5	5
		H/Dayo	40	32	5	3
		H/Eba	40	40	0	0
W/Hararghe	Habiro	Kufakas	40	35	2	3
		Qufa	40	38	0	2
		Bareda	40	37	1	2
W/Hararghe	Daro labu	Oda Anesso	40	38	0	2
		Kotora	40	36	2	2
		H/Adii	40	37	0	3
E/Hararghe	Babile	Kile (Besidimo)	40	34	0	6
		Bishan Babile	40	36	2	2
		Tofik	40	40	0	0
E/Hararghe	Fedis	Edobaso	40	36	0	4
		Umerkulle	40	36	2	2
		Bal'ina arba	40	40	0	0
E/Hararghe	Kurfachalle	Dire gudina	40	38	0	2
		Ija kechu	40	37	0	3
		Jiru gemachu	40	40	0	0

N: Number of the respondents, W: West, E: East.

Severity of Striga

About 20% of the growers explained that Striga could be used for animal feeding. Nevertheless, many of the respondents 80% said that Striga has no advantage and they have not used for multipurpose. Consequently, this detrimental effect of Striga reduces crop yield and shelter for pests and diseases. In general, the severity of disadvantage dominates its advantage in the study area (Table 4). Therefore, due to the high infestation of Striga and maximum sorghum yield loss was occurred. This assessment in agreement with Ejeta (2007) who studied the infestation *Striga hermonthica* and *Striga asiatica* in cereal crops and cause significant yield loss.

Table 4. Farmers' responses on striga severity, disadvantage, and advantage in percentage

Zone	District	Village	Disadvantage (%)	Advantage (%)	N	Severity
W/Hararghe	Gemachis	H/Riana	35	5	40	Highly severe
		H/Dayo	40	0	40	Severe
		H/ Eba	40	0	40	Severe
W/Hararghe	Habro	Kufakas	32	8	40	Highly severe
		Qufa	40	0	40	Severe
		Bareda	40	0	40	Severe
W/Hararghe	Darolabu	Oda Anesso	40	0	40	Severe
		Kotora	33	7	40	Highly severe
		H/Adii	40	0	40	Severe
E/Hararghe	Babile	Kile-Besidimo	30	10	40	Highly severe
		Bishan Babile	40	0	40	Severe
		Tofik	40	0	40	Severe
E/Hararghe	Fedis	Edobaso	31	9	40	Highly Severe
		Umerkulle	34	6	40	Severe
		Bal'ina arba	32	8	40	Highly severe
E/Hararghe	Kurfachale	Dire gudina	33	7	40	Highly severe
		Ijakechu	36	4	40	Severe
		Jiru gemachu	40	0	40	Severe

N: Number of respondents, W: West, E: East

Perception of Farmers' on the Mechanism of Striga Seeds Dispersal

Mechanism of Striga Seeds Dispersal

The large number of farmer household respondents said, wind, animals, water runoff (flood) and contaminated crop seed with Striga seed dominated the dispersal means because farm crops are harvested at the time when the Striga weed had flowered. When the animals move, they carry the seed of Striga with their body, mud feet and feather so easily dispersed. Farm machinery was rated less because most farms have less use tractors and combine harvester. They use their hand farm tools hence less dispersal mechanism (Figure 4).

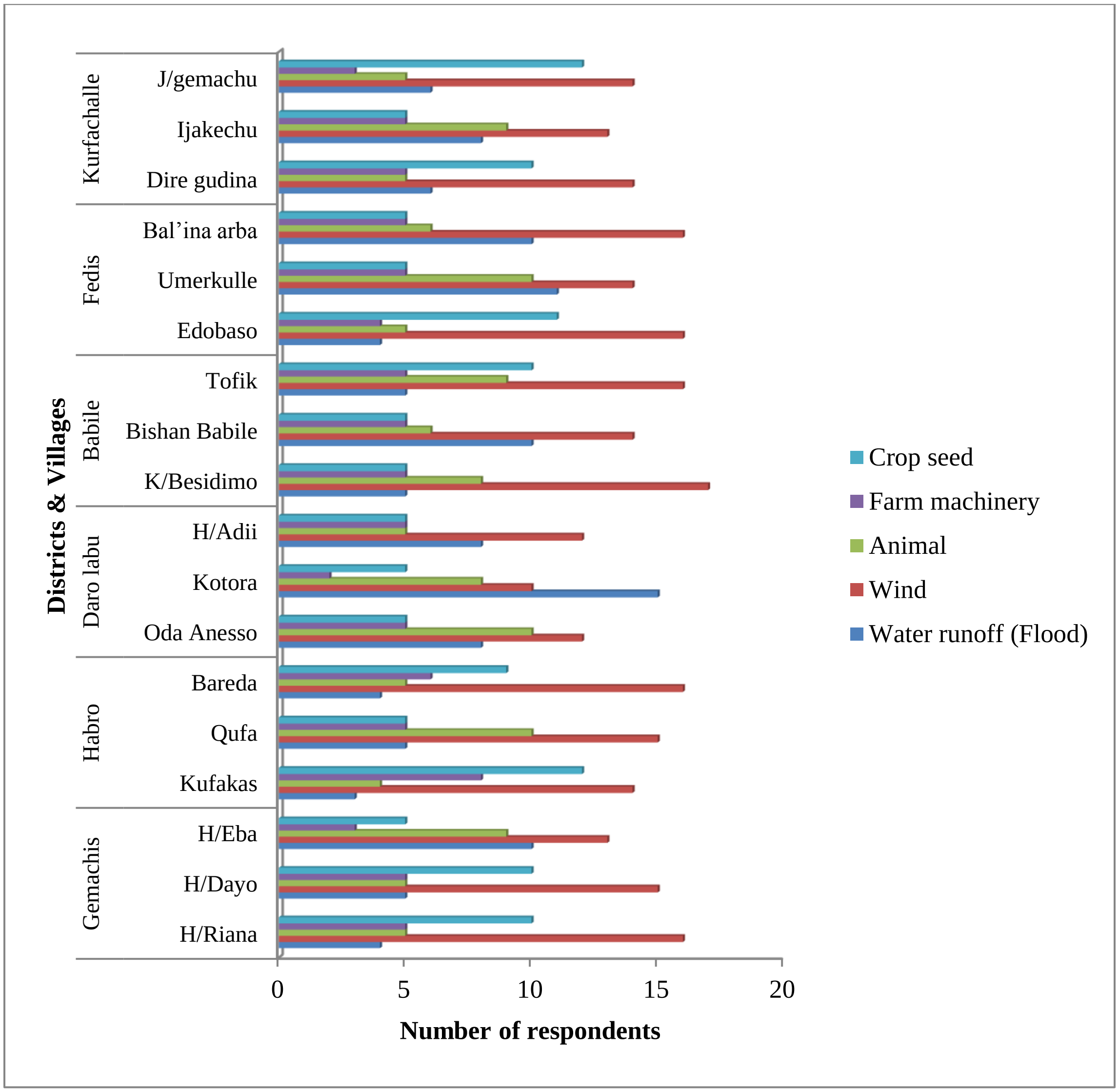

Figure 4. Farmers' responses on the mechanism of *Striga dispersal* to their Farm fields.

Farmers' Responses on the Rate of Striga Dispersal and Its Effect on the Host Crops

Based on Farmers' responses and actual observation *Striga hermonthica* was common throughout surveyed area and extended from east Hararghe to west Hararghe zones in six districts. The seed of Striga easily disseminates from one place to other by different dispersal mechanisms and longevity without loss viability. This increases the rate of Striga dispersal and a wider distribution in each district (Figure 5).

According to household respondents, *Striga hermonthica* has marked effects on the growth and yield of their host crops. The parasite more damaging and devastating under drought and low soil fertility conditions. The respondents said, during Agronomic practices, it difficult to thin sorghum seedlings due to Striga attached the root of sorghum. This assessment agrees with Dafaallah et al. (2016) who explained that the Striga life cycle is subterranean; growing entirely at the expense of its host and the parasite inflicts most of its damage to the host during this phase of its life cycle. Symptoms displayed by infected hosts, include stunting, toxic' effects, reduction of internode expansion, wilting, chlorosis, reduced photosynthetic rate and decreased growth and yield. According to the figure, most respondent percentages gave high infestation (increasing, medium and low) rate of Striga in each district.

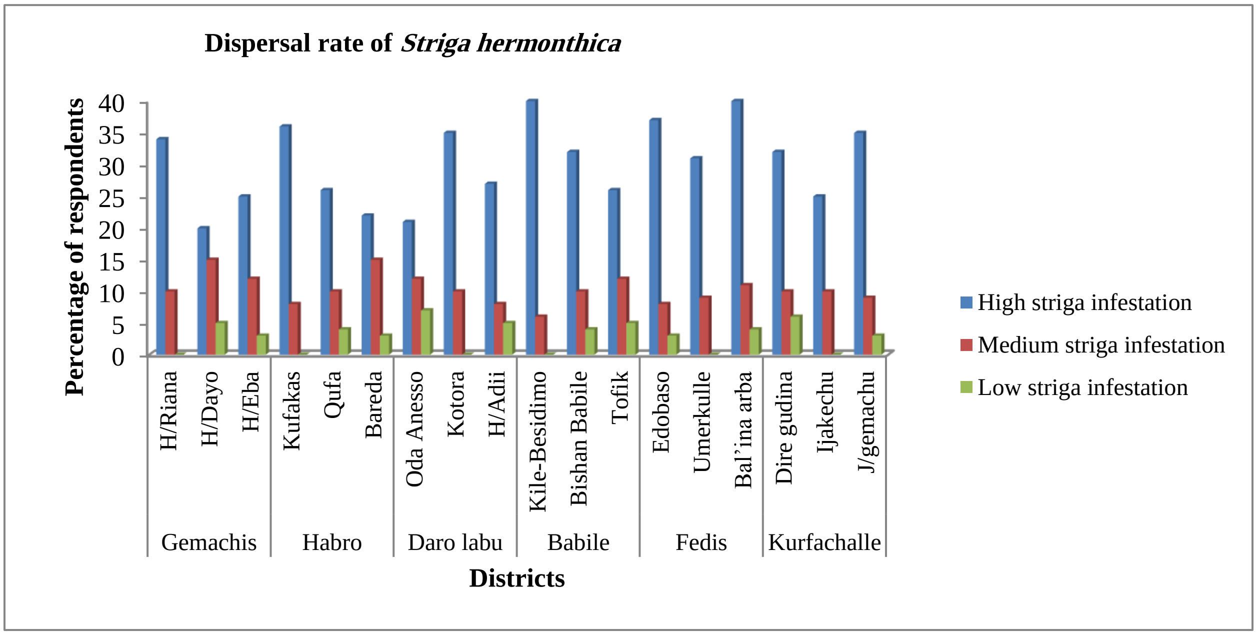

Figure 5. Farmers' responses on the dispersal rate of *Striga hermonthica* in surveyed districts.

Farmers Awareness on the status of Soil Fertility

Based on the farmers' response and actual observation soil fertility in the surveyed area was categorized as high, medium and low soil fertility. Accordingly, about 5% of the respondents explained the soil fertility in the surveyed area is high, 25% of the farmers said medium and the majority of the growers 70% said the soil fertility is low (Table 5) which is favorable for Striga invasion. The assessment is promising with Atera et al. (2011) and Larsson (2012) which explanation high Striga infestations occurred due to infertile soils. Thus, the large number of Striga infestation exists across all the study sites in low soil fertility and drought. This judgment is also in covenant with the findings of Samaké et al. (2005) which indicated that the infestation of Striga is intensely related with the decline of soil fertility.

Farmers Response on Sorghum Production Constraints

In the surveyed area majority of growers explained the constraints that influence ~~the~~ sorghum production. Among the constraints that contributed to low sorghum yields, drought, low soil fertility, high striga infestation, pests, diseases, birds and less production inputs. Farmers' ranking of production constraints across districts showed that 75% of the respondents ranked moisture stress and Striga infestation as highly important constraints. Striga caused severe yield losses in sorghum in all studied districts. The importance of this parasitic weed may be attributed to high occurrence due to the production of large numbers of seeds per plant and multiple dispersal mechanisms (Koichi et al. 2010). Moderate infestations 20% were reported by some farmers, probably those who practiced regular weeding and Agronomy. About 50% of the farmers ranked that shortage and lack of awareness on production inputs.

Overall, all the studied districts are Striga infested areas with low soil fertility. Such environmental conditions in covenant with the explanations of Wortmann et al. (2009) who stated that low sorghum yields in eastern Africa were associated with nutrient deficiencies, drought, Striga and stem borers. These severity constraints were different from district to district and within a district (Figure 6).

Table 5. Farmers' responses on the soil status and season in which *Striga* infestation worst.

District	Village	Number of respondents	Infertile soil & Dry season	Fertile soil and Short Rain season	Fertile soil & Long rain season
Gemachis	H/ Riana	40	38	2	0
	H/Dayo	40	36	4	0
	H/Eba	40	40	0	0
Habro	Kufakas	40	37	3	0
	Qufa	40	40	0	0
	Bareda	40	34	6	0
Daro labu	Oda Anesso	40	36	4	0
	Kotora	40	34	6	0
	H/Adii	40	32	8	0
Babile	Kile-Besidimo	40	35	5	0
	Bishan Babile	40	36	4	0
	Tofik	40	33	7	0
Fedis	Edobaso	40	28	12	0
	Umerkulle	40	30	10	0
	Bal'ina arba	40	29	11	0
Kurfachalle	Dire gudina	40	32	8	0
	Ija kechu	40	34	6	0
	Jiru gemachu	40	35	5	0

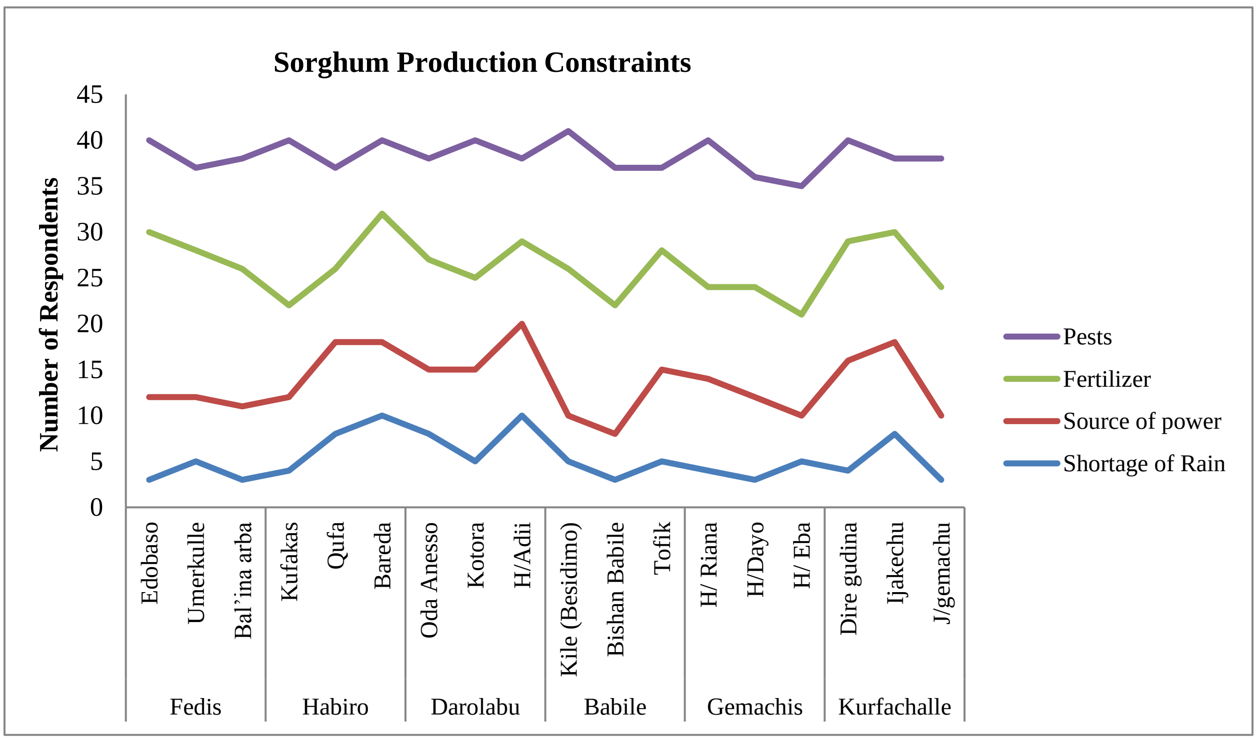

Figure 6. Farmers' responses on sorghum production constraints in the surveyed site.

Farmers' Perception on Factors in Hindering the Appropriate Management of Striga

In general, about 40% of the farmers' respondents in the surveyed area are not adequately aware of moisture conservation practices, inadequate crop resistance variety, crop rotation, and lack of labor (Figure7). These farmers have no enough information about Striga seed bank and sowing legumes can minimize Striga infestation for the next crop.

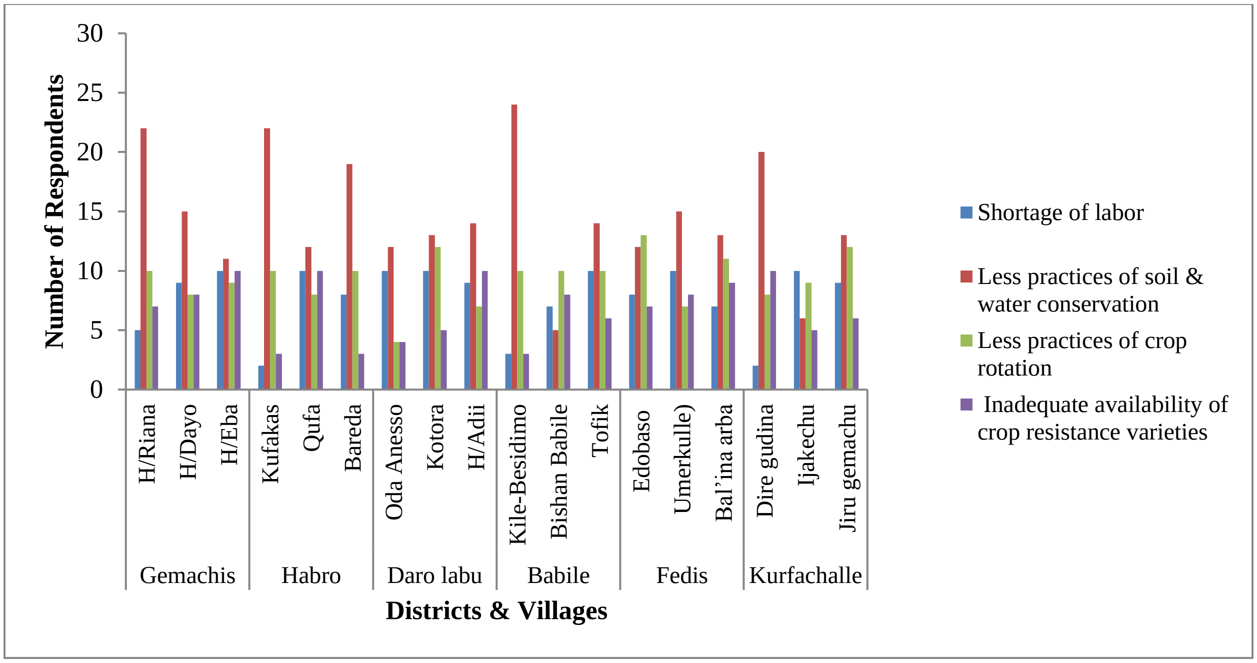

Figure 7. Growers' opinion on factors hindering the appropriate striga control.

Farmers' Responses on the Strategies in the Management of Striga

Farmers Perception on Striga Control

In the surveyed areas, most of the respondents believed that the Striga affected the host plants immediately after its emergence from the ground. Hand weeding, crop rotation, adjusting planting date, legume intercropping, and resistance varieties were some of the coping mechanisms reported by the farmers for reducing Striga infestations. About 50% of the farmers used hand weeding in their sorghum fields to reduce Striga infestation. Farmers tried to manage Striga without considering the parasite's growth stage; some weeded before flowering, while others after flowering. Weeding after flowering of the parasite may contribute to increasing subsequent infestations. Therefore, there are several methods to combat Striga. The result agrees with Joel (2014) who stated that suitable agricultural practices for the Striga management.

Based on farmers' perception all management measures are not practiced in all the surveyed sites. But each control measure is categorized as the most significant or very effective, partially effective, and no effective control measures for Striga in the studied area (Figure 8).

Willingness of the Community for Collective Actions to Manage or Prevent Striga

The household respondents in the surveyed area were agreed with various Striga management systems/plan such as Striga free seeds, use of sufficient amount of fertilizer, crop rotation, legume intercropping, use of herbicide, moisture conservation, hand weeding before flowering and they promised to restrict different mechanisms by which Striga distributes from one field to other fields. The farmers' respondents also promised to change their regularly growing crops from susceptible hosts to Striga resistant cultivars. Majority of Farmers' respondents promised to use integrated Striga control mechanisms in the surveyed sites (Table 6).

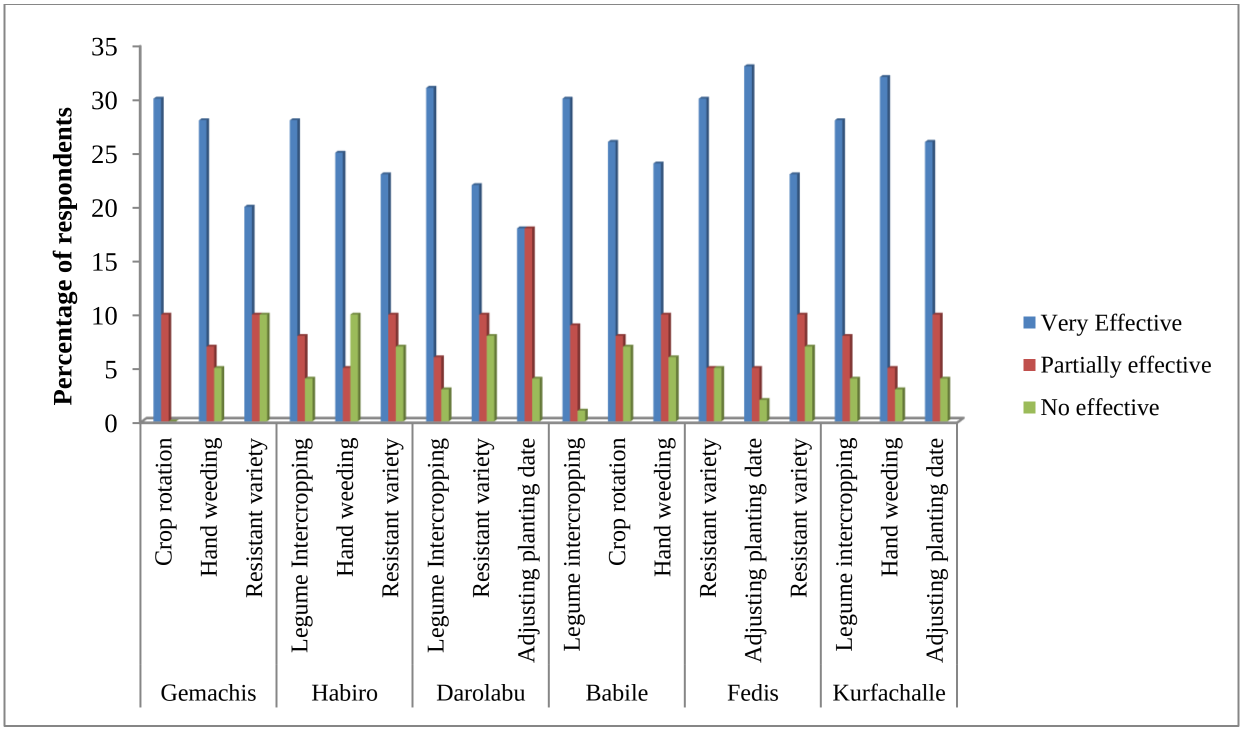

Figure 8. Farmers' responses on the methods used to prevent/control Striga.

Table 6. Willingness of the Farmers' for collective actions to manage Striga in the future

Zone	Districts	Villages	Legume intercropping	Use of herbicide	Integrated striga control	Hand weeding before flowering	Crop rotation
W/Hararghe	Gemachis	H/ Riana	15	5	7	8	5
		H/Dayo	7	3	10	10	10
		H/Eba	12	4	9	7	8
W/Hararghe	Habiro	Kufakas	10	5	5	10	10
		Qufa	8	4	10	8	10
		Bareda	11	5	10	4	10
W/Hararghe	Darolabu	O/Anesso	13	7	5	10	5
		Kotora	10	8	10	6	6
		H/Adii	9	9	5	10	7
E/Hararghe	Babile	Besidimo	12	3	10	7	8
		B/Babile	8	5	7	10	10
		Tofik	10	4	10	8	8
E/Hararghe	Fedis	Edobaso	10	10	10	5	5
		Umerkulle	12	8	6	7	7
		Bal'ina arba	10	5	10	8	7
E/Hararghe	Kurfachale	D/gudina	14	6	6	6	8
		Ijakechu	9	4	7	10	10
		J/gemachu	10	5	10	7	8
Total number of respondents			190	100	147	141	142

W: West, E: East.

The respondents also decided to work with the district agricultural experts and other organizations to serve Striga management technologies to the growers.

Conclusion

This survey indicated that *Striga hermonthica* was distributed over all the surveyed areas. However, its abundance was not even across the sites. The expansion of *Striga hermonthica* was more on farmlands with moisture stress areas. Currently, *Striga hermonthica* has increased, and its spread has a negative impact on the local people. To improve its negative influence many of the growers tried to manage it, however its dissemination is increasing from period to period for the reason that some farmers did not use all an appropriate Striga management system. Sorghum is the most commonly produced among the cereals grown in the surveyed area and stable food crop for the local people, but *Striga hermonthica* is creating to be a challenge for sorghum production. As a result of this, the local people become food unsecured and affecting their socio-economic activities. The assessment of Striga abundance, distribution and the socio-economic impact was inadequate in scope and geographical coverage. Therefore, detailed investigation should be sustained in the future to cover large areas. This will tolerate for definite conclusion on socio-economic, distribution and abundance of *Striga hermonthica* in the region.

Conflicts of Interest

No conflicts of interest have been declared.

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