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Assessment of the Invasive Alien Plant Species *Argemone ochroleuca* in North Gondar and West Gojam Zones, Amhara Region, Ethiopia

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Abstract: Biological invasions are attracting far reaching attention from ecologists because of their significant ecological impacts and economic costs worldwide. They are more and more recognized as a key problem of conservation of biological diversity. *Argemone ochroleuca* is one of invasive worldwide plant. In Ethiopia its distribution is increasing from time to time. Therefore, the objective of this study was to assess the impacts, mode of entry, trends, status, distribution and management practices of *Argemone ochroleuca* in selected districts of North Gondar and West Gojam Zones. Accordingly, an assessment was carried out in Dembiya, Gondar and Bahir Dar Zuria and Yilmana Densa districts, in 80 randomly selected households from eight different *Kebeles* (the smallest administrative unit in Ethiopia). Based on the interview and field observation, the level of *Argemone ochroleuca* invasion was very high and it was the most dominant IAS on disturbed land, range land, roadside, main field, home garden and near river in the study areas. From the total respondents, 97.6% reported that *Argemone ochroleuca* had caused a high level of damaging impacts on native biodiversity in the past and most of them (98.7%) worried about its negative impacts on biodiversity in the future. Based on the respondents report, *Argemone ochroleuca* was introduced to the study area by different mechanisms such as flood, animal's body, along with improved seed varieties and transport materials. Majority of the respondents (87.5%) recommended that to control the spread of *Argemone ochroleuca* in the future additional investigation is needed by concerned body. Therefore, Governmental and Nongovernmental Organizations should find a mechanism to eliminate this Invasive Alien plant and save the farm and grazing lands before becoming out of control.

Keywords: *Argemone ochroleuca*, Biodiversity, Biological Invasions, Invasive Alien Species

1. Introduction

Biological invasion is a form of biological pollution that is probably more disastrous than the chemical pollution which is considered as the second greatest global threat to biodiversity after habitat destruction [5, 25]. Invasive Alien Species' refers to a species subspecies or lower taxon, introduced outside its natural past or present distributions which are widely distributed in all kinds of ecosystems throughout the world including all categories of living organisms [4, 10]. The main invasion routes are: introduction by chance (unintentionally) and introduction by hand (intentional introduction of horticultural, medicinal, silvi cultural or agricultural plants for economic purpose) [6, 21, 25].

Biological invasions are attracting far-reaching attention from ecologists because of their significant ecological impacts and economic costs. They are more and more recognized as a key problem of conservation of biological diversity, Reichard and White (2003) cited in [11, 26]. Particularly, Invasion by plant species poses a major threat to native plant communities and alters fundamental structures and functions of ecosystems [7, 12, 21, 25, 30].

Argemone ochroleuca is invasive worldwide that is native to Mexico and naturalized in most warm countries of the world in sub-humid as well as semiarid regions. It is now a principal invasive common weed of many vegetable and crop fields in various countries. It is found in a wide range of environments. However; it is most common in semi-arid, sub-tropical and warmer temperate regions [9, 12, 28]. It reproduces by producing a large number of seed which may fall naturally to the ground [22, 23]. The majority of seeds are dispersed by floodwaters. It is also possible for the whole plant to break off at the base which can be blown by the wind in to new areas. It can grow and persist in disturbed areas and farmland where it can compete and potentially displace native biodiversity [9, 22, 24]. The formation of dense stands, as seeds fall locally, also affects wildlife and decreases biodiversity which is commonly found as a weed of road sides, mining dumps, rabbit warrens, recently cultivated paddocks, waste places, and overgrazed pastures [8, 14, 20, 23, 24].

Argemone ochroleuca is an invasive medicinal plant with economic potentialities [1, 3, 15, 22, 27]. However, these uses cannot compensate its overall negative impacts. It is extremely poisonous to livestock and humans. The main danger to livestock, horses and poultry usually comes from fodder and other stock feeds that have become contaminated with its leaves or seeds [16, 20, 24, 28, 31]. Its prickly nature also causes injury to humans and livestock. It also reduces the yield of many cereals, native biodiversity and causes damage to animal/plant products [12, 19, 24, 28].

Consequently, effective management practices are a must to control the impacts of *Argemone* ochroleuca. The best form of invasive species management is prevention [23]. As *Argemone* ochroleuca is so widespread, this is unlikely to be possible in many instances. If prevention is no longer possible, it is best to treat the weed infestations when they are small to prevent them from establishing. Controlling the weed before it seeds will reduce future problems [13, 31] and generally best applied to the least infested areas before dense infestations are tackled. Consistent follow-up work is required for sustainable management. Control of young plants of *Argemone* ochroleuca can be achieved by hand pulling and repeated slashing prior to seed set. However, due to thorns, hand pulling may be painful. The matured plant can be grubbed or cut before fruits ripen. The seedlings can be mowed; however, mowing and slashing are often unsuccessful due to re growth [12, 20, 26].

The impact of invasive weeds on environment, article 8 (h) of the Convention on Biological Diversity (CBD) signed by 161 countries at the Earth Summit in 1992; urges the parties to "prevent the introduction of, control, or eradicate those alien species which threaten ecosystem, habitat or species "and Ethiopia being a member of (CBD) has to play its role judiciously. As in many other countries in the tropics hundreds of alien species have been introduced to Ethiopia, intentionally and/ or unintentionally [5, 10, 11] but little is known about their impacts, distribution patterns, management practices and status.

Argemone ochroleuca is one those IAS commonly found in Amhara, Oromiya and SNNPR, Ethiopia. Its distribution is increasing from time to time. The farm and grazing lands are highly invaded by this plant. The number of pods produced per a single plant and number of seeds produced per single pod is too much to create devastating effects to native plant species when germinate [14, 16, 20, 23, 24, 28]. However, no adequate recent information exists about the impacts, distribution pattern, trend, status and controlling mechanisms of this species. Therefore, this research aims at assessing the impacts, distribution pattern, trend, management practices and statuses of *Argemone* ochroleuca in selected districts of North Gondar and West Gojam Zones, Amhara region, Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area

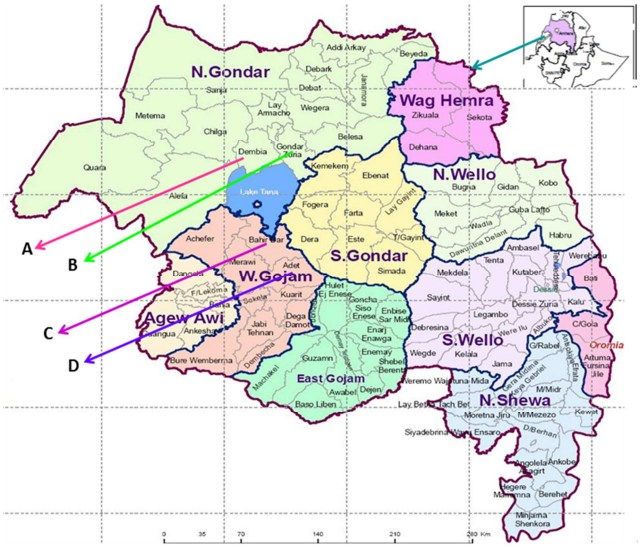

Fig. 1. *Administrative Map of the study area (A: Dembiya, B: GondarZuria, C: Bahir Dar Zuria, D: Yilmana-Densa [Adet]).*

North Gondar is a Zone in the Ethiopian Amhara Region. This Zone is named for the city of Gondar, the capital of Ethiopia until the mid-19th century, which has often been used as a name for the 20th century province of Begemder. North Gondar is bordered on the south by Lake Tana, West Gojjam, AgewAwi and the Benishangul-Gumuz Region, on the west by Sudan, on the north by the Tigray Region, on the east by Wag Hemra and on the southeast by Debub Gondar [29]. Based on 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this Zone has a total population of 2,929,628, of whom 1,486,040 are men and 1,443,588 women [2].

West Gojjam is a Zone in the Amhara Region of Ethiopia. West Gojjam is named after the former province of Gojjam. West Gojjam is bordered on the south by the Abay River which separates it from the Oromia and Benishangul- Gumuz Regions, on the west by AgewAwi, on the north west by North Gondar, on the north by Lake Tana, and the Abay

River which separates it from the Debub Gondar, and on the east by East Gojjam [29]. Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this Zone has a total population of 2,106,596, of whom 1,058,272 are men and 1,048,324 women [2].

2.2. Method of Data Collection

Field study on the impacts, trends, mode of entry, spread, status, distribution and management practices of *Argemone ochroleuca* in North Gondar zone (Dembiya and Gonder Zuria districts) and West Gojam zone (Bahir Dar Zuria and Yilmana- Densa districts) of Amhara region was conducted. The study zones and districts were selected purposively on the basis of the level of *Argemone ochroleuca* invasion with the help of information obtained from Agricultural office of Amhara region.

Based on the above selection criteria, from the two zones four districts were selected. From four districts the study was conducted only on eight representative *kebeles*. From each district two *kebeles* were selected based on the level of invasion of *Argemone ochroleuca* according to the information obtained from districts agricultural office. Accordingly, Yinesa-sositu, Wondata, Adet-zuria, Abika, Zengachi, Layiye-Duge, Mesikele-Kirisitos and Jangwa-Mariam were selected to conduct this research. From each *Kebele* 10 households were selected randomly bringing the total number of sampled households to 80.

Data was collected from primary sources. The primary data was collected through Semi-structured interview and Field observation. Secondary source of data was obtained from the agricultural office of the districts, from different books, journal and research article.

2.3. Method of Data Analysis

The collected data was analyzed by using SPSS (statistical package for social sciences). A descriptive statistical method was employed to analyze and summarize the data and to calculate percentages, frequency and mean. Inferential statistical method was also employed. Linear Regression Analysis (using SPSS) was used to predict the value of a variable based on the value of another variable.

The number of years the respondents living in the study area was taken as the independent variables while number of invasive alien species mentioned by the respondents were taken as the predicted variable or dependent variable or outcome variable.

3. Results and Discussions

3.1. Households Characteristics

From the total respondents, most of the households' heads (63.8%) had age between 36 and 50 years old, while only a few household head (1.3%) had age between 12 and 20 years old, 17.5% of the households had age between 21 and 35 years old. Similarly 17.5% of the households' heads had age greater than fifty (>50) years old. As to the sex of the respondents, most of them were males (83.8%) and only a few of them were females (16.3%). Concerning to the education status of the respondents, 21.3% of them were uneducated, 30.0% of them studied informal education while 45.0% of them studied primary education and 3.8% them were educated up to Secondary High School (9–10). The educational status of the households' heads was from uneducated households' heads up to Secondary high School (9–10). Regarding to the marital status of the respondents, 95% of them were married, 1.3% of them was unmarried and 3.8% of them were divorce. As to number of years the respondents lived in the study *Kebeles*, 1.3% of them lived less than 10 years, while 17.5% and 2.5% of them lived 11-30 and greater than 60 years respectively. Most of the respondents (78.8%) lived 31-60 years in the study areas.

3.2. Respondents Estimate on the Status of Argemone ochroleuca

The majority of respondents (81%) indicated the invasive plant species, Argemone *ochroleuca,* has high level of infestation in the study area whereas 18.7% of them indicated that it has intermediate level of infestation. Similar study by [20] on *Argemone ochroleuca* reported that it has high level of infestation in Dahod District, Gujarat, India and it is also one of the most hazardous invasive wild weeds, flourishing nearly in all drastic habitats in arid and semi-arid regions of the world [28].

In this study, the lion share of informants (95%) indicated that *Argemone ochroleuca* infestation is increasing at an alarming rate and insignificant informants (5%) indicated its infestation is decreasing in the study area. The variation on the current spread of *Argemone ochroleuca* between informants may be because of the respondent's exposure to neighbor *kebeles* otherwise the level of infestation is increasing at an alarming rate from time to time as per of the majority informants view and our direct observation (Table 1). The previous study by [24] reported as it is a new invasive species in Andhra Pradesh state, India and its infestation also increasing at alarming rate from time to time which is almost similar to the result of the current study.

Table 1. *Comparison of the previous and current spread of Argemone ochroleuca.*

Zone of the respondents		Level of infestation		Total
		Decreasing	Increasing	
West Gojam	Count	0	40	40
	% of Total	0.0%	50.0%	50.0%
North Gondar	Count	4	36	40
	% of Total	5.0%	45.0%	50.0%
Total	Count	4	76	80
	% of Total	5.0%	95.0%	100.0%

From the recruited 80 individuals, 73.8% agreed that *Argemone ochroleuca* has got out of control in their local areas and only 26.3% participants disagreed with that it is out of control in the study areas. The occurrence of *Argemone ochroleuca* is not restricted to any of environmental and crop management variables recorded, e.g. altitude, soil type,

rainfall, or crop species [14, 30].

From field observation and the respondents report the most dominant invasive alien species in the study area was *Argemone ochroleuca* which occurred in all respondents land followed by *Cirsium vulgare* (81.3%) and *Parthenium hysterophores* (80%) respectively. Other invasive alien species such as *Striga hermonthica, Xanthium strumarium, Orobanche crenata, Cuscuta campestris, Nicotiana glauca etc*. are commonly found in the study area (Table 2). In addition unidentified invasive species were reported by most of the respondents (56.3%). Similar study by [24] reported that *Argemone ochroleuca* is found in association with *Argemone Mexicana* and other invasive species. Other similar study by [16] also reported that 35 desert weed species, with different life forms belonging to 25 different families are associated with *Argemone ochroleuca*.

Fig. 2. *Level of Invasion of farmland by Argemone ochroleuca in the study area (Photo by: Niguse Seboka and Amare Seifu).*

Table 2. *Lists of Invasive Species recognized by the respondents (with Frequency and Percent) in the study area.*

No.	List of Invasive Species	Frequency	Percent
1	*Argemone ochroleuca*	80	100
2	*Xanthium strumarium*	60	75
3	*Orobanche crenata*	31	38.8
4	*Parthenium hysterophorus*	64	80
5	*Lantana camara*	50	62.5
6	*Senna didymobtrya*	47	58.8
7	*Cuscuta campestris*	53	66.3
8	*Xanthium spinosum*	46	57.5
9	*Eichhornia crassipes*	38	47.5
10	*Striga hermonthica*	51	63.8
11	*Calotropis procera*	32	40
12	*Nicotiana glauca*	24	30
13	*Cirsium vulgare*	65	81.3
14	*Argemone mexicana*	13	16.3
15	*Senna occidentalis*	12	15
16	Unidentified	45	56.3

The study proved that there were considerable variations with the numbers of Invasive Species mentioned by respondents and numbers of years the respondents living in the study area. As the number of years the respondents living in the study area increase, the number of Invasive Species mentioned by them also increases. Hence the regression equation can be presented as Y:=0.21X–3.082, where Y is number of Invasive Species mentioned by the respondents and X is number of years the respondents living in the study area. R– square value indicates how much of the dependent variable can be explained by the independent variable. In this case, R^2=0.580 or 58% of the dependent variable can be explained by the independent variable; this is quite adequate result. Moreover, the result of this study showed that there is a strong positive linear relationship (i.e. one variables increases with other) between number of Invasive Species mentioned by the respondents and number of years the respondents living in the study area (R=0.76). This is logical that as the number of years the respondents living in the particular area increases their knowledge about that area also increases or in this particular cases, number of Invasive Species recognized by the respondents increases (Fig. 3).

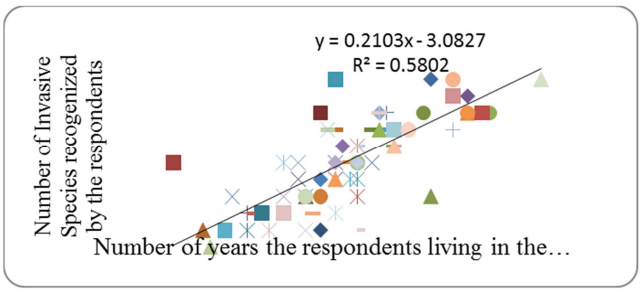

Fig. 3. *Relationship between number Invasive Species mentioned by the respondents and number of years the respondents living in the study area (R^2=0.580, p<0.005).*

3.3. The Mode of Entry and Spread of Argemone ochroleuca

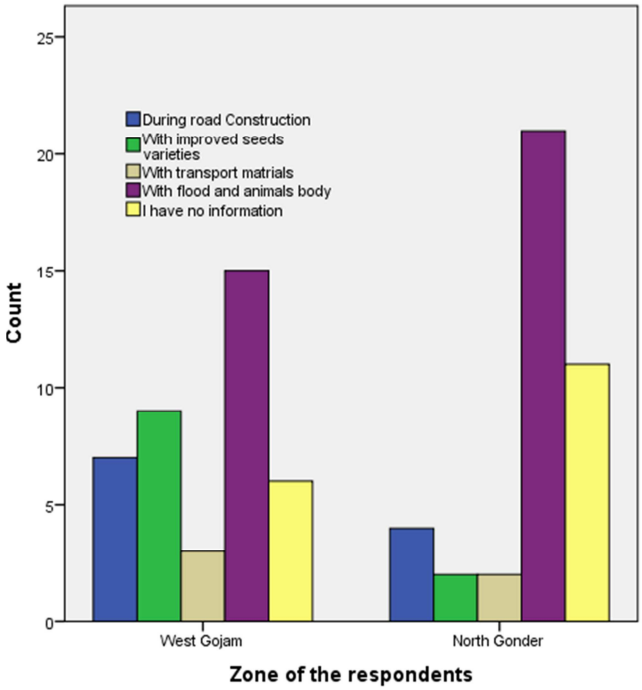

Fig. 4. *Modes of introduction of Argemone ochroleuca.*

According to the informants view, the invasive plant species, *Argemone ochroleuca,* is introduced by different mechanisms. A little below half of the respondents (45%) reported its mode of entry by means of flood and animals body. Others (21.3%) replied that they had no right

information how it was introduced in their locality. On the other hand, 13.8% of the respondents indicated *Argemone ochroleuca* was introduced during road construction and along with improved seed varieties. The remaining reported its means of spread through transport materials (Fig. 4).

Concerning to the means of spread of *Argemone ochroleuca*, 28.8% of the respondents reported as easily dispersed by flood, animals, wind and vehicles, 1.3% by trade and having long dormancy period, 23.8% of them reported as due to the presence of many seeds per pod, 21.3% of them responded as lack of awareness to control its spread and 24.8% of them reported as easily dispersed by flood, animals, wind, vehicles, trade, the presence many seeds per pod and lack of awareness to control its spread.

Other similar study by [28] reported that *Argemone ochroleuca* produces huge number of fruits that range from 162 to 258 per individual. The number of seeds per fruit ranges from 433 to 473. So an overall maximal number of 122,160 seeds per individual plant while a minimal overall number of 70,515 seeds were detected. It was observed that seeds produced in large quantities tend to fall near the parent plant producing dense stands. The plant is known to break off at the base and be windblown for long distances helping to disperse seeds. The immense numbers of produced seeds evinces the high propagation of the species. The species is characterized by its high propagation ability that affects to a large extent the rangeland ecosystems [16]. The previous study by [16] and [28] confirmed that the large numbers of produced seeds helps the high propagation of the species which has been also mentioned by the respondents in the current study.

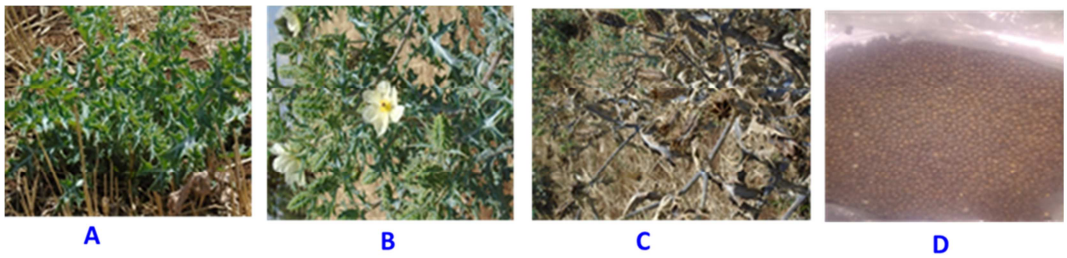

Fig. 5. *Argemone ochroleuca (habit prior to flowering) (A) and habit of mature plant (flower stage) (B), Matured pod (C), Seed (D) (Photo by Nigusse Seboka and Amare Seifu).*

Concerning from where *Argemone ochroleuca* introduced to the study area, the majority of informants (71.3%) reported that they had no information from where *Argemone ochroleuca* had been introduced to their locality. Others 8.8% and 10% of informants indicated that they knew only the mechanisms of introduction that probably from where construction materials and improved crops came respectively whereas 10% of informants declared it was introduced from Sudan.

In other way, respondents reacted differently based on their empirical observation on the time of introduction of *Argemone ochroleuca* to their environment. From the total respondents 31.3% of them assumed that it was introduced to their locality before 2 up to 5 years whereas 25% of them reacted that it was introduced before 6 up to 10 years, 11.3%, 6.3% and 15% of them replied that it was introduced before 11 up to 20, 21 up to 31, 21 up to 30 and 31 up to 40 years respectively. Similar study by [14] reported as *Argemone ochroleuca* originated from the region of Central America and south-western North America. Nowadays, they are wide spread around the warmer parts of the world such as Latin America, Africa and Asia.

Regarding to the area invaded by *Argemone ochroleuca,* most of the respondents (38.8%) informed that the main field, home garden, disturbed land, range land, road side and near river are the areas mostly invaded by it; while 5%, 2.5%, 17.5%, 10.0%, 12.5% and 13.8% them reported as main field, home garden, disturbed land, range land, road side and near river respectively are the areas invaded by *Argemone ochroleuca*. Similar study by [28] reported that *Argemone ochroleuca* commonly found as a weed of road sides, mining dumps, rabbit warrens, recently cultivated paddocks, waste places, and overgrazed pastures. It often occurs as dense stands in sandy stream beds and alluvial flats associated with intermittent in land streams.

3.4. Impact of Argemone ochroleuca

More than half of the respondents (53.8%) reported that *Argemone ochroleuca* causes human and animal injury, invades agricultural and rangeland, computes biodiversity and takes time to clean while 23% of them reacted that it has a harmful effect by invading agricultural and rangelands and 12% of them believed it has a negative effect on biodiversity through competition, whereas insignificant number of them (6.3% and 1.3%) reported it has a detrimental negative impact on human and animal as well take time to clean, respectively.

Argemone ochroleuca is now a principal invasive common weed of many vegetables and crop fields in various countries [8]. It reduces the yield of many cereals such as wheat as its seed is an undesirable contaminant in stock sold food. The structure of native plant communities and the fauna are affected by invasiveness of this species [23]. Moreover, similar study by [14] reported that in eastern parts of Ethiopia *Argemone ochroleuca* occurs as awed with pulses, cereals, tobacco, tea, and sugarcane, tomatoes, cotton and potato causing reduction of their yield significantly.

Concerning to the negative impacts of *Argemone ochroleuca* on Biodiversity, almost all of the respondents

(98.8%) reported that *Argemone ochroleuca* has negative impact on biodiversity where as only 1.3% of them replied as they have no information about the negative impact of it. It can grow and persist in disturbed areas and farmland where it can compete and potentially displace native biodiversity. The formation of dense stands, as seeds fall locally, also affects wildlife and decreases biodiversity. Besides being competitive weeds in agriculture, *Argemone* species are toxic: seeds confused with those of mustard, and if it is consumed, can lead to illness and even death [3].

From a total of 80 recruited individuals, 97.6% agreed that *Argemone ochroleuca* had caused a high level of damaging impacts on biodiversity in the past. Of these individuals, 58.8% and 38.8% preferentially explained that the level of damaging impacts of *Argemone ochroleuca* had been increasing in a slight and sharp manner, respectively. Only two individuals claimed for the decrement of the level of its negative impacts on biodiversity in the pastime (Table 3).[16] reported that *Argemone ochroleuca* had caused high level of damaging impacts on animal /plant products and reduced native biodiversity which is almost similar to the result of the current study.

Table 3. *The level of the negative impacts of Argemone ochroleuca on biodiversity in the past.*

Zone of the respondents		Decreased slightly	Increased slightly	Increased sharply	Total
West Gojam	Count	0	19	21	40
	% of Total	0.0%	23.8%	26.3%	50.0%
North Gondar	Count	2	28	10	40
	% of Total	2.5%	35.0%	12.5%	50.0%
Total	Count	2	47	31	80
	% of Total	2.5%	58.8%	38.8%	100.0%

As to the coverage of negative impacts of *Argemone ochroleuca* on biodiversity in the past time, 88.8% of the respondents agreed with the wide spread and over all coverage (throughout) of the negative impacts of it on biodiversity in the study areas during the past time. The pattern of agreement regarding to its negative impact coverage was: localized-1.30%, Scattered-10.00%, wide spread-62.5%, and throughout -26.3% (Table 4).

Table 4. *The coverage of the negative impacts of Argemone ochroleuca on biodiversity in the past.*

Zone of respondents		Localized	Scattered	Widespread	Throughout	Total
West Gojam	Count	1	5	22	12	40
	% of Total	1.3%	6.3%	27.5%	15.0%	50.0%
North Gondar	Count	0	3	28	9	40
	% of Total	0.0%	3.8%	35.0%	11.3%	50.0%
Total	Count	1	8	50	21	80
	% of Total	1.3%	10.0%	62.5%	26.3%	100.0%

Almost all respondents (98.7%) worried about the negative impact of *Argemoneo chroleuca* on biodiversity in the future. From the total (80) respondents, 6.30% and 92.50% agreed that it will cause either high or very high negative impacts on biodiversity in the future, respectively. In contrast, only one individual claimed for the moderate negative impacts of it in the future time (Table 5). The Invasiveness of *Argemone ochroleuca* will be very high in the future due to highly adaptable to different environments, mobile locally, proved invasive outside its native range and tolerant of shade [14, 16, 20, 24, 28] which is almost similar to the current study.

Table 5. *The negative impact of Argemone ochroleuca on biodiversity in the future.*

Zones of respondents		Moderate	High	Very high	Total
West Gojam	Count	0	4	36	40
	% of Total	0.0%	5.0%	45.0%	50.0%
North Gonder	Count	1	1	38	40
	% of Total	1.3%	1.3%	47.5%	50.0%
Total	Count	1	5	74	80
	% of Total	1.3%	6.3%	92.5%	100.0%

3.5. Economic and Other Uses Argemone ochroleuca

Most of the respondents (82.5%) reported that *Argemone ochroleuca* has no benefit and 17.5% of them reacted as if it has benefit. Concerning to the type of benefit that the societies obtained from *Argemone ochroleuca* 11.3% of them used it as lubricant ("*Masesha"*) during baking 'injera' and 5% of them use as traditional leather lubricant. The remaining insignificant number of them uses it for traditional medicine, as animal feed and ornamental plant.

The economic importance of *Argemone* species could be concluded as sources of oil and renewable energy, Singh and Singh (2010) cited in [16] and alkaloids Singh *et al*. (2010) cited in [16]. It was also, reported as a medicinal plant, Deka (2007) cited in [16]. In modern medicine, the latex of *Argemone ochroleuca* has antibacterial activities against human pathogenic bacteria [1, 15]. The latex is useful in curing skin diseases, leprosy, blisters, conjunctivitis, inflammation, burning sensation and malarial fever. Moreover, the drug prepared from this herb is used to treat

the problem caused by tapeworm [17]. In Mexico, *Argemone ochroleuca* is used in traditional medicine to treat eye infections, spots, warts, insomnia, cough and dermatological disorders [18, 27]. The current assessment study and the previous experimental study are somewhat analogous although insignificant number of respondents reported the use of *Argemone ochroleuca* as traditional medicine in the study area.

3.6. The Management Practices to Control Argemone ochroleuca in the Study Area

Concerning to the organization that has been working on control of *Argemone ochroleuca,* almost all of the respondents (98.8%) confirmed that there was no organization that has been working on control of *Argemone ochroleuca*. Only 1.3% of the respondents reported that there was one governmental organization that has been working on control of it such as agricultural office.

Regarding to the technique or practice that the local community used to control the spread of *Argemone ochroleuca*, 30.0% of them reported the local community used cutting at young stage and burn it to control the spread of it, while a little below half of them (46.3%) control its spread by digging out at young stage and burn it, 6.3% of them control its spread by cutting before fruiting and burn it, 8.8% of them reported as using chemical, 7.5% them reported the spread of it controlled by cutting at young stage and burn it, by digging out at young stage and burn it, cutting before fruiting and using chemical and only insignificant number of them had no information concerning to the technique or practice that the local community used to control the spread of *Argemone ochroleuca* (Fig. 6).

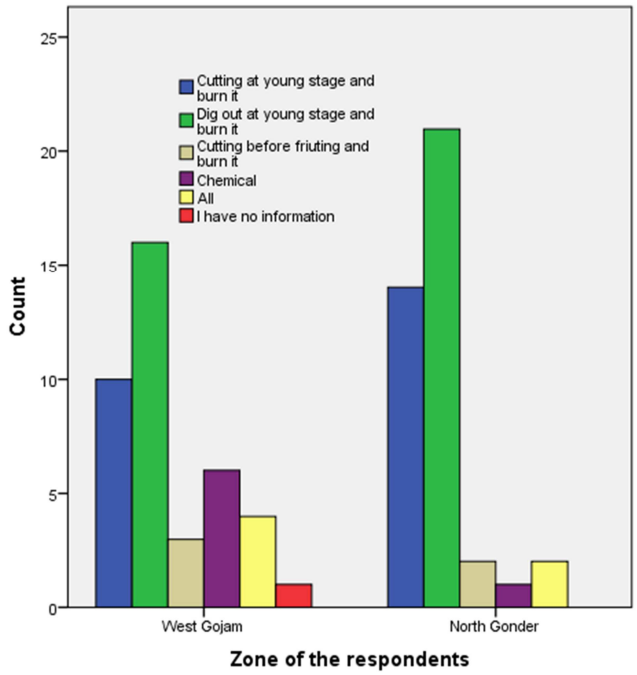

Fig. 6. *The technique or practice that the local community used to control the spread of Argemone ochroleuca.*

As to the effective technique or practice applied by the local community to control the spread of *Argemone ochroleuca*, about 51.3% of the respondents replied that they use manual/mechanical (dig out at young stage and burn it) methods to effectively control the spread of it, about 38.8% of them reported that there is no effective control method, about 8.8% of them replied that they use chemical/ nonselective weed killer to effectively control the spread of it, where as only 1.3% of them responded that they use selective weed killer to effectively control the spread of *Argemone ochroleuca*.

Regarding to the suggestion of the study participants about the best practices that the local people should use to control the spread of *Argemone ochroleuca* in the future, 87.5% of them suggested that the control of the spread of *Argemone ochroleuca* in the future needs further investigation by concerned body and majority of them believed the government, communities and non-governmental organizations should work together in order to control the spread of *Argemone ochroleuca*. However, 11.3% and 1.3% of them suggested that it can be controlled by digging out at young stage and by means of non selective weed killer (chemicals), respectively. [13, 23, 28, 31] reported almost similar results concerning different management practices to control *Argemone ochroleuca*.

4. Conclusions and Recommendations

Many IAS are introduced intentionally or unintentionally for various purposes. *Argemone ochroleuca* is one of IAS that invaded many ecosystems and communities in Ethiopia, in general disturbing ecosystem structure, function and reducing native biodiversity. Currently, it is invading the main field, home garden, disturbed land, range land, road side and near river of North Gondar zone (Dembiya and Gondar Zuria districts) and West Gojam zone (Bahir Dar Zuria and Yilmana-Densa districts), Amhara region, Ethiopia. This assessment study indicates the severity of the invasion in these areas. Therefore, the Governmental and Nongovernmental organizations should find a mechanism to eliminate this invasive plant and save the farm and grazing lands before becoming uncontrolled.

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