

Impact and status of invasive alien plant species (IAPS), *Nicotiana glauca*, in Eastern and Southern Zones of Tigray regional state, Ethiopia

Abstract

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. They are more and more recognized as a key problem of conservation of biological diversity. *Nicotiana glauca* is one of IAPS that poses a threat to biodiversity by competing with native species for resources and displacing native plants. In Ethiopia its coverage is increasing from time to time. Therefore, the objective of this study was to assess the impacts, routes of entry, way of spread, trends, status, distribution and management practices of *Nicotiana glauca* in selected districts of Eastern and Southern Zones of Tigray Region. Accordingly, an assessment was carried out in Embalaje and Hawuzen districts. All respondents (100%) agreed about the invasiveness of *Nicotiana glauca*. Majority of the respondents (96.6%) agreed that the level of its invasion has been increasing from time to time. Majority of the respondents (61.7%) reported that *Nicotiana glauca* has been causing different damage to the community such as minimize the growth of other plants, expand and compete to agricultural and communal land, toxicity and death of livestock and also human. Researcher's personal observation and results of these studies revealed that *Nicotiana glauca* covers most of communal lands, grazing fields and road side of the study areas. Therefore, all concerned bodies should actively share their effort to tackle the biodiversity loss by this dangerous Invasive Alien Plant Species.

Keywords: invasive alien plant species, biodiversity, *Nicotiana glauca*, toxicity

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Abbreviations: IAS, invasive alien species; CBD, Convention on Biological Diversity; SPSS, Statistical Package for Social Sciences; IAPS, invasive alien plant species; GISD, global invasive species database

Introduction

Background of the study

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.¹ Invasive species are widely distributed in all kinds of ecosystems throughout the world including all categories of living organisms. The main invasion routes are: introduction incidentally (unintentionally in shipping containers, lurking under the bark of log imports, infesting fruits carried by tourists, swimming in ballast water exchanged in a harbor, quietly reproducing in the intestines or bloodstream of an unsuspecting travelers, or hidden in soil of imported ornamental plants) and introduction by hand (intentional introduction of horticultural, medicinal, silvicultural or agricultural plants for economic purposes that escape from captivity).²

Invasive Alien Species' means an alien species whose introduction and/or spread threatens biological diversity; alien species' refers to a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs of such species that might survive and subsequently reproduce. Several thousands of the alien species have become established in different parts of the world over the past couple of centuries.³

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.⁴ Particularly, invasion by plant species poses a major threat to native plant communities and alters fundamental structures and functions of ecosystems.^{1,2,5,6,7}

Nicotiana glauca is one of Invasive Alien Plant Species that poses a threat to biodiversity by competing with native species for resources and displacing native plants. *Nicotiana glauca* has been included in the Global Invasive Species Database (GISD). It has been listed as a noxious weed in South Africa (prohibited plants that must be controlled). They serve no economic purpose and possess characteristics that are harmful to humans, animals or the environment. Within its native range *Nicotiana glauca* is an occasional plant of dry, naturally and anthropogenic ally disturbed areas such as river banks, track sides and abandoned quarries. It is found mainly in semi-arid environments from low to high altitudes, but never at wet localities. *Nicotiana glauca* is a conspicuous, profusely blooming invasive species growing predominantly along roadsides and on disturbed land in semi-arid regions.⁸

Nicotiana glauca is toxic to human and animals. Unlike other members of the *Nicotiana* genus, *Nicotiana glauca* does not contain the alkaloid nicotine. However, it produces a similar compound called anabasine, which is highly toxic to humans and animals. Anabasine is more toxic than nicotine and can cause fatal deformities in livestock when the mother ingests small amount of the plant material during early pregnancy.⁹

Nicotiana glauca contains the piperidine pyridine alkaloid, anabasine, which is closely related to nicotine, derived from *Nicotiana tabacum*. Anabasine acts as an agonist at peripheral nicotinic receptors. The nicotinic receptors of the autonomic ganglia and the neuromuscular junctions are initially stimulated, but this is invariably followed by prolonged blocking. Strong stimulation of the central nervous system also occurs resulting in tremors followed by convulsions. Death is ascribed to respiratory paralysis.¹⁰

Nicotiana glauca grows in a wide variety of open and disturbed habitats including roadsides and lakeshores. It is mainly a problem in relatively dry areas. *Nicotiana glauca* poses a threat to biodiversity by competing with native species for resources and displacing native plants. All parts of the plant are poisonous. 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, control, or eradicate those alien species which threaten ecosystem, habitat or species” and Ethiopia being a member of (CBD) has to play its role thoughtfully. In Ethiopia the impact, status, management practices, distribution patterns and trend of *Nicotiana glauca* is not well studied. *Nicotiana glauca* is widely distributed in Tigray, SNNPR and central Oromia regions, Ethiopia. However, less attention is given to the studies of this Invasive Alien Plant Species in Ethiopia and no investigation has been undertaken since then. Therefore, this research aims at assessing the impacts, routes of introduction, status, management practices, distribution patterns and trend of *Nicotiana glauca*, in Embalaje and Hawuzen districts of Tigray region, Ethiopia.

Materials and methods

Description of the study area

Tigray Region is the northernmost of the nine regions of Ethiopia. Tigray is the homeland of the Tigray, Irob and Kunama people. Its capital is Mek’ele. Tigray is bordered by Eritrea to the north, Sudan to the west, the Afar Region to the east, and the Amhara Region to the south and southwest. Besides Mek’ele, major cities include Hawzen, AbiyAddi, Alamata, Mekoni, Adigrat, Adwa, Axum, Humera, Korem, Maychew, Qwiha, Shire, Wukro and Zalambessa. There is also the historically significant town of Yeha (Figure 1).¹¹

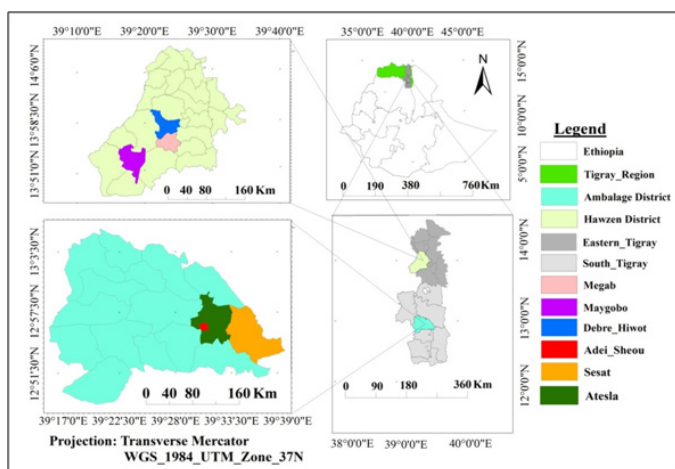


Figure 1 Administrative map of the study area.

Method of data collection

This study was conducted in Embalaje and Hawuzen districts, Tigray regional State, Ethiopia. The study districts were selected purposively on the basis of the level of *Nicotiana glauca* invasion with the help of information obtained from Agricultural office of Tigray region. Based on the above selection criteria, from the two zones two districts were selected. From two districts the study was conducted only on six representative kebele Egrealba (Hadishom), Maigebo, Atsela, Soset, Megab and Debrehiwot. From each district three Kebeles were selected based on the level of invasion of *Nicotiana glauca* according to the information obtained from districts agricultural office. From each Kebele 10 households were selected purposively bringing the total number of sampled households to 60 to study the status, trend, distribution pattern and management practices of *Nicotiana glauca*.

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.

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.

Results and discussion

Households characteristics

A total of 60 respondents, 48 [80%] males and 12 [20%] females, were interviewed from March to April 2017. The age of respondents varied from 19 to 85 years old with mean age of 48.23±14.89 years. Majority of the respondents (88.3%) were married, 8.3% of them were divorced and insignificant number of the respondents were unmarried (3.3%). As to number of years the respondents lived in the study areas, majority of the respondents (95%) lived between 19 and 74 years, while the minimum and the maximum years the respondents lived in the study areas were 2 and 75 years respectively with mean 46.9±15.54. Regarding to their education status, 19(31.7%) were uneducated, while 11(18.3%) had informal education, 29(48.3%) had attended either primary or secondary school education or insignificant number of the respondents 1(1.7%) had attended higher education.

Level and status of *Nicotiana glauca*

All respondents (100%) agreed that they were aware about the invasiveness of *Nicotiana glauca*. This is also confirmed by personal observation of researchers during the study period. Also, 76.6% agreed that the level of infestation of *Nicotiana glauca* is either high or very high in the study area and 21.7% claimed that the level is medium in their local area (Table 1) (Figure 2).

Majority of the respondents (96.6%) agreed that the level of *Nicotiana glauca* invasion has been increasing from time to time (Table 2).

Table 1 Respondents statement about the level of *Nicotiana glauca* in their locality

	Frequency	Percent	Cumulative percent
Low	1	1.7	1.7
Medium	13	21.7	23.3
High	38	63.3	86.7
Very high	8	13.3	100
Total	60	100	



Figure 2 Status of *Nicotiana glauca* in the study areas.

Table 2 Respondents statement about the previous and current spread of *Nicotiana glauca* in the study area

	Frequency	Percent	Cumulative percent
Decreases	1	1.7	1.7
Increases	35	58.3	60
Highly increases	23	38.3	98.3
Remain constant	1	1.7	100
Total	60	100	

Route of introduction and Spread of *Nicotian aglauca*

Regarding to the main route of introduction of *Nicotiana glauca* in the study districts, respondents argued that it was introduced either by animals (16.6%) or it instantly occurred (15%); besides, 16.7% of the respondents claimed that it was introduced either deliberately for medicinal use or with agricultural tools or with dumping soil during road construction. Despite these, (51.7%) of the respondents in the study districts had no information about how *Nicotiana glauca* was introduced in their local area. Majority of the respondents reported that *Nicotiana glauca* can easily spread within short period of time and resists to drought.

As reported by,¹² the structural characteristics of *Nicotiana glauca* were thickness of the cell wall, the greater density of both the vascular system and stomata, and the increased development of the palisade tissue at the expense of the spongy tissue which is assumed to be associated with arid habitats. It is also believed that the arrangement

of these tissues within the leaf is responsible for maximum utilization of light. The other important factor which is assumed to enhance the photosynthetic efficiency was the presence of well-developed systems of intercellular spaces which might be involved in facilitating rapid gas exchange.¹²

Although few respondents (6.7%) claimed that *Nicotiana glauca* was introduced either from Eritrea (5%) or from where road construction materials come from (1.7%), majority of them (93.3%) had no information from where *Nicotiana glauca* was introduced to their local area.

Concerning to the mechanisms of spread, majority of the respondents (91.7%) informed *Nicotiana glauca* easily dispersed by flood, animals, wind and vehicles in view of the fact that it has many and light seeds. The remaining (8.3%) related the mechanism of spread of *Nicotiana glauca* to the presence of long dormancy period of the seeds, its resistances to drought and lack of awareness to control its spread.¹³ Reported that the partial tolerance to drought and salinity in *Nicotiana glauca* resides in its ability to achieve water conservation through stomatal closure and osmotic adjustment and reduce absorption of excess radiation through the presence of leaf wax. Moreover, the study conducted by¹⁴ indicated that *Nicotiana glauca* is a quickly growing glabrous and big shrub which is able to produce about 10,000 to 1000,000 very small seeds.

Almost all of the respondents (98.3%) informed that road side, near compound, wetland and river are the main habitats which are mostly invaded by *Nicotiana glauca*. Insignificant number of the respondents (1.7%) did not know the areas that were invaded by *Nicotiana glauca*. The result of the study by,¹⁵ *Nicotiana glauca* is a cosmopolitan bird-pollinated plant, distributed in warm temperate, arid and subtropical, dry and moist regions, beside roadsides and along riverbanks, up to altitudes of 3000m. The reason for such good adaptation of the species, *Nicotiana glauca*, in new habitats might be its known capacity of self-pollination with probably successful self-fertilization. Moreover, it is known that *Nicotiana glauca* produces a large quantity of seeds dispersed mostly by wind, has early reproductive maturity, a rapid rate of growth, grazing and drought resistant and tolerant to a wide range of environmental conditions.

Impact of *Nicotiana glauca*

Majority of the respondents (61.7%) reported that *Nicotiana glauca* has been causing different damage to the community such as poison and kill livestock and human, minimize the growth of other plants, expand and complete agricultural and communal land. Of these a little below half of the respondents (28.3%) stated that *Nicotiana glauca* was poisoning and killing their livestock when they eat any part of the plants but only a few respondents (3.3%) reported that *Nicotiana glauca* was poisoning and killing human. In contrast to this, 35% of the respondents reported that *Nicotiana glauca* had no effect and insignificant number of the respondents (3.3%) did not know the negative impact of *Nicotiana glauca* in the study area.

The study by¹⁶ indicated that congenital defects may also be seen with anabasine toxicosis. Cleft palate and multiple congenital contractures, such as torticollis, scoliosis, lordosis, and arthrogryposis, have been observed in goats, cattle, pigs, and sheep after the dams ingested plants containing anabasine. The degree of phytotoxicity of different *Nicotiana glauca* parts is ranked in the following order of inhibition: leaves > flowers > fruit > stems > roots.^{17,22}

Regarding to the benefits of *Nicotiana glauca*, majority of the respondents (88.3%) reported that it had benefits in the study areas. Of these 36.7% of the respondents reported that *Nicotiana glauca* used as traditional medicine and for fence, 28.3% of them used as traditional medicine and wind break, 10% for fence and house construction, 5% of them reported as its flower used for bee and the remaining respondents (8.3%) replied that *Nicotiana glauca* used as fire wood, compost and to control soil erosion. In contrast to this, 11.7% of the respondents reported that *Nicotiana glauca* had no use in the study areas.

Nicotiana glauca is considered as a toxic plant in some places. However,¹⁸ reported that *Nicotiana glauca* is a folk remedy for boils, headaches, piles, sores, wounds and cancer. In addition, the fraction of *Nicotiana glauca* has shown high antioxidant potential. The result of different study indicated that *Nicotiana glauca* possesses potent antitumor and antioxidant activities.

Regarding to the organisms that are highly harmed by *Nicotiana glauca* the majority of respondents (58.3%) did not know which plant or animal was specifically affected by the *Nicotina glauca* in the study area. On the other hand, 28.3% of the respondents replied that *Nicotina glauca* was harming livestock, grass and 11.7% of the respondents indicated that *Nicotina glauca* was seriously affecting cattle, cereals and chickpea (*Cicer arietinum*).^{19,20} Reported that *Nicotiana glauca* has both toxic and medicinal properties. For several decades, *Nicotiana glauca* has been known for its content of the pyridine alkaloid, anabasine. Anabasine is quoted to be a very toxic alkaloid not solely to insects.²¹

Concerning to the estimated amount of money lost due to the damage by *Nicotiana glauca* per year, 35% the respondents did not recognized its impacts, 28.3% reported as if it was difficult to estimate and insignificance number of the respondents (5.1%) reported as 8000_15,000 Ethiopian Birr. Regarding the level of negative impact of *Nicotiana glauca* on biodiversity, majority of the respondents (66.6%) reported that the negative impact of *Nicotiana glauca* on biodiversity increase slightly and sharply and 31.7 % of the respondents stated as remained constant whereas insignificant number of the respondents (1.7%) indicated that the negative impact of *Nicotiana glauca* decreased slightly (Table 3). This agree with^{12,17} to the study on preliminary screening of leaf extract of *Nicotiana glauca* has the strongest allelopathic effect on seed germination, thus the allelopathic impact of leaf extract was more powerful than other vegetative parts. Moreover, in the growth assay, radicle and shoot lengths of target species were found to be affected by different aqueous extracts of *Nicotiana glauca*. Radicle length was strongly inhibited by aqueous extracts of leaves and flowers of *Nicotiana glauca* for all the test species. The reduction ranges from 15%-97% for radish, 68%-100% for lettuce, 29%-90% for peganum and 98%-100% for cardoon. *Nicotiana glauca* aqueous extracts are able to inhibit root length more than shoot [17].

Table 3 Level of the negative impact of *Nicotiana glauca* on the biodiversity in the past

	Frequency	Percent	Cumulative percent
Decrease slightly	1	1.7	1.7
Remain constant	19	31.7	33.3
Increase slightly	32	53.3	86.7
Increase sharply	8	13.3	100
Total	60	100	

Concerning to the coverage of the negative impact of *Nicotiana glauca*, 53.3% of the respondents reported that the impact coverage of *Nicotiana glauca* in the past was widespread and 26.7% of them replied as localized coverage. The remaining 20 % of the respondents confirmed that the impact coverage of *Nicotiana glauca* was scattered (10%) and throughout (10%) (Table 4). The result showed that despite the infestation is in its infant stage, the plant has a widespread coverage impact in the past.

Table 4 The coverage of the negative impact of *Nicotiana glauca* on biodiversity in the past

	Frequency	Percent	Cumulative percent
Localized	16	26.7	26.7
Scattered	6	10	36.7
Widespread	32	53.3	90
Throughout	6	10	100
Total	60	100	

Concerning to the negative impact of *Nicotiana glauca* on biodiversity, 43.3 % of the respondents reported that its impact will be mild and 31.7% of them reported as high impact, whereas the remaining 16.7% and 8.3% of the respondents reported that its impact will be moderate and very high respectively (Table 5). Regarding to whether *Nicotiana glauca* get out of control or not in the study areas, majority of the respondents (88.3%) reported that *Nicotiana glauca* was not get out of control whereas the remaining insignificant number of respondents (11.6%) replied, the species was not out of their control. The result indicated that if actions will be taken in time, the species is at the stage of easily manageable.

Table 5 The negative impact of *Nicotiana glauca* on biodiversity in the future

	Frequency	Percent	Cumulative percent
Mild	26	43.3	43.3
Moderate	10	16.7	60
High	19	31.7	91.7
Very high	5	8.3	100
Total	60	100	

Management Practices

Based on the information obtained from the respondents and field observation, *Nicotiana glauca* covers most of communal lands, grazing fields and road side of the study areas. Farmers only worried on control of *Nicotiana glauca* from their own farmlands. As to the technique or practice that the local community used to control the spread of *Nicotiana glauca*, majority of the respondents (90%) used mechanical methods such as digging out and cutting at younger stage and burn it to clear from their farm lands. The remaining respondents (10%) had no information about the technique or practice that the local community used to control the spread of *Nicotiana glauca*.

As to the possible best practice that will be applied by the local people to control the spread of *Nicotiana glauca* in the future, half of the respondents (50%) believed that to control the spread of *Nicotiana glauca* in the future, it needs further investigations and awareness creation program by concerned body, 20% of the respondents reported that dig out and burn it is appropriate to control the spread of *Nicotiana glauca* in the future while 30% of them reported that

awareness creation program by concerned body is needed to control the spread of *Nicotiana glauca* in the future.

Regarding to the organization that has been working in the control of *Nicotiana glauca*, all of the respondents (100%) informed that there was no organization that has been working in the control of *Nicotiana glauca*. On the other hand, the organization that will be involved in the control of *Nicotiana glauca*, almost all of the respondents (98.3%) believed that in the control of *Nicotiana glauca*, the societies, the government and non-governmental organization should be better to work together.

Conclusion and recommendation

Many Invasive Alien Plant Species are introduced intentionally or unintentionally for various purposes. *Nicotiana glauca* is one of Invasive Alien Plant Species 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, disturbed land, range land and road side of Central and South Tigray (Hawuzen and Embaaje districts), Tigray 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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Conflict of interests

Author declares that there is no conflict of interest.

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