Volume 9, Issue 7, July – 2024 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL370

A Systematic Review on the Distribution of Invasive Plant Species Across Asia: Assessing the Rates of Invasion Success and Management

J Caparic[1*]; LCM Cargo[2]; CJ Gaston[3]; D Sta. Rosa[4]; JL Resuello[5]; C Parmis[6]
Jasper Caparic, Lovely Crissa Mae Cargo, Cyrell Gaston, Daniel Sta. Rosa, John Lester Resuello, Christopher Parmis, Chemical Engineering Technology Department, Technological University of the Philippines – Taguig, Taguig City

Corresponding Author:- J Caparic[1*]

Abstract:- The advancement of invasive plant species in a particular environment is threatening across Asia. When they are introduced, they could have a variety of different negative effects, either as minor inconveniences or a severe problem. The aim of this review is to compile a list of invasive plant species across Asia and organize a set of data according to their reproduction rates, growth rates, dispersal rates, and characterize the allelochemicals they produce and allelopathic effects they have on their environment. The target is to know the extent of their spread ability in the area that they inhibit and know what control measures can be done with that specific species. The data has been gathered by compiling research articles and obtaining pertinent data relating to the objective. This review also utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist to confirm the credibility of the collected references. To achieve the needed references, keywords such as "distribution", "invasive", and "Asia" have been used to search for these on search engines and research journals such as Google Scholar, ScienceDirect, ResearchGate, and Directory for Open Access Journals, to be then compiled in spreadsheets and document files. The results show that the growth rate of these species varies from 7.5-60 cm per year, where Ipomoea eberhardtii has the highest growth rate of 60 cm per year. The dispersal rates of the species ranges from 0.002-2592 km from the parent plant, where animal mediated, water, and wind dispersal methods are the primary vector to spread. Allelopathic effects produced by the allelochemicals present mostly inhibit growth and seed germination. There are already implemented approaches to control these species, where biological control, physical means, and the use of chemicals are the most used strategies. In different dynamic processes, physical and chemical control measures are most utilized in this case.

Keywords:- *Allelochemicals, Dispersal, Exotic, Growth, Pattern, Spread.*

I. INTRODUCTION

The introduction of different exotic floras and wide distribution of invasive alien species in forest ecosystem are threatening the biodiversity across Asia. The emergence of new IAPS of novel ecosystem have been showing an intimidating concern over the past decade in the diversity of native plants yet remain an overlooked issue until now.

Interestingly, it has been a matter of debate among invasion ecologists whether IAPS are the first/second-most severe threat (only 27.3% are in favor of this) or they should be ranked further below. The anthropogenic perturbations caused by biotic invasion does not only poses problems environmentally but also to the human well-being often in negative and sometimes, positive manner (Prabhat & Singh, 2020). Because of their pollen and toxins, invasive plant spread on a worldwide scale, especially in disturbed places like landfills and dumps (which can become epicenters for invasive plant species), can have a significant negative impact on human health (Plaza et al., 2018). Numerous IAPS have been observed to be invading both terrestrial and aquatic ecosystems worldwide.

Natural plant communities that are in good health offer wildlife, insects, and soil biota with a sustainable environment. They can withstand droughts and support ecosystem services like fresh water and air. When invasive plants are brought into a native plant community, there may be a variety of negative outcomes, ranging from slight inconveniences to significant issues. For instance, a non-native species may coexist in the community with very little impact, or it may be extremely invasive and completely alter it. In the latter case, invasive species can produce large numbers of highly viable seeds, outcompete native plants for water and nutrients, and profit from highly adaptable life strategies that let them make the most of available resources (Wacker, 2022). The coexistence between native and exotic species exhibits a functional and niche differences that may alter the natural habitat of plants and exacerbate competition.

This systematic review aims to address three key objectives: (1) Identify and compile a comprehensive list of invasive plant species introduced across Asia; (2) Investigate the reproduction rates and strategies employed by invasive plant species, analyzing their reproductive success, seed production, and dispersal mechanisms; (3) Identify and characterize the allelochemicals produced by invasive plant species and its potential allelopathic effects on native vegetation and ecosystem processes; and (4) Evaluate the impacts of invasive plant species on native ecosystems and biodiversity across Asia, assessing the extent of their spread, competition with native species, habitat modification, and disruption of ecosystem processes

II. METHODOLOGY

The paper adhered to particular criteria and employed a thorough methodology to extract and amalgamate evidence-based literature and practices.

➢ *Data Gathering*

For gathering of data in this systematic review, a comprehensive and structured approach is adopted. Specific inclusion while establishing exclusion criteria to ensure the selection of pertinent studies. Keywords and search terms related to the topic were also used to retrieve potential studies. The search results are then screened in two stages: title and abstract review followed by full-text review. Data extraction forms were used to systematically collect relevant information from the selected studies, including study design, population characteristics, interventions, outcomes, and results. This data is then organized and synthesized to provide a comprehensive understanding of the topic under review, ensuring transparency and reproducibility of the process

➢ *Data Sources*

In order to enhance the quality of the review process, the researchers utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist to validate the credibility of the selected references. For this review, a variety of search engines and databases, including ScienceDirect, Google Scholar, ResearchGate, and Directory of Open Access Journals, were employed to identify pertinent published articles, research papers, and scientific reports.

➢ *Search Strategy*

The search terms commonly used were “distribution,” “invasive,” and “Asia.” Initial consideration was given to the first 100 relevant articles, with a preference for open-access resources. Additionally, grey literature sources such as government and non-government reports, international organization websites, news articles, and policy documents were explored for relevant information.

➢ *Framework of the Study*

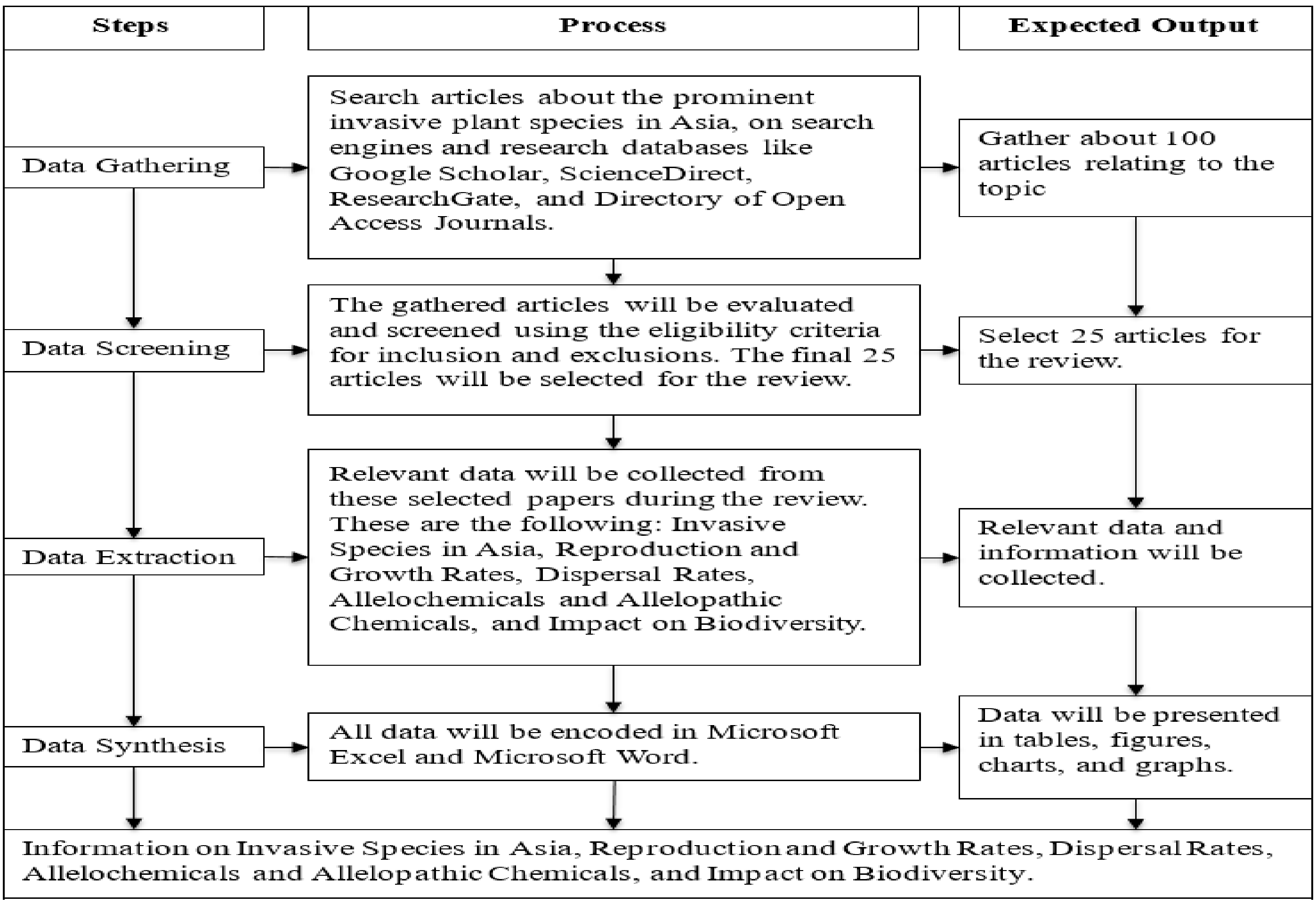

Fig 1 Schematic Diagram Representing the Flow and Process of the Study

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL370

➢ *Exclusion and Inclusion Criteria*

All relevant articles included in this review were categorized based on the following criteria: (1) Studies focusing on invasive plant species across Asian regions; (2) Studies that have data of the rates of invasion success; (3) Studies published after 2017. Studies were excluded from this review (1) Studies focusing on invasive plant species outside of Asia; (2) Studies with inadequate methodology or study design that does not allow for the assessment; (3) Studies that do not provide data or analysis on the determinants of invasion success; (4) Studies published before 2017.

➢ *Data Extraction and Analysis*

The study utilized Microsoft Excel to organize the collected references and Microsoft Words to present the findings, incorporating graphic organizers for clarity. The researcher coded the data using keywords, created themes by grouping related codes, and reviewed and revised them for accuracy. The identified themes encompassed plant species' distribution, reproduction, growth, dispersal, allelochemicals, and ecological impacts. A total number of 100 studies were initially identified from the combination of search terms from four database (23 from ScienceDirect, 66 from Google Scholar, 15 from ResearchGate, and 8 from Directory of Open Access Journals). Using the eligibility criteria, a total of 25 studies out of the 100 articles were selected in this paper to ensure that only studies meeting the pre-set criteria were included in the review. This step helped to minimize bias and ensure that the selected studies were of high quality and relevance to the research question. Data extraction was then carried out systematically, with relevant information from each selected study being extracted and synthesized. The extracted data were then analyzed using appropriate statistical methods to identify patterns and trends in the spread of invasive plant species.

III. RESULTS

In the results section focusing on invasive plant species in Asia, we first detail their reproductive characteristics, highlighting strategies such as prolific seed production and efficient vegetative reproduction. Quantitative data on seed numbers per plant, germination rates, and reproductive phenology are provided, alongside comparisons between native and invasive populations where applicable. This also includes the examination of dispersal mechanisms, emphasizing modes like wind, animal-mediated, and human-mediated dispersal that facilitate their spread across diverse Asian habitats. We quantify dispersal distances and discuss adaptations enhancing dispersal efficiency, such as specialized propagules. Regarding growth rates, we present data on height or biomass accumulation over time, analyzing factors like environmental conditions and competitive interactions with native species. The interplay between reproduction, dispersal, and growth is explored to elucidate how these factors collectively contribute to the invasive success of these species in Asia, offering insights crucial for effective invasive species management and conservation strategies.

➢ *List of Invasive Plant Species Across Asia*

Table 1 Invasive species in Asia

Name of species	**Common name**	**Country of origin and natural habitat**	**Country of distribution in Asia**	**Growth Rate per year (cm)**
Acacia mangium	Black wattle	Australia and Papua New Guinea	Southeast Asia	40
Ageratina Adenophora	Crofton weed	Mexico	Southern India and Southeast Asia	10
Ageratum conyzoides	Billygoat-weed	Brazil	East Asia, Philippines & India	15
Ambrosia trifida	Giant Ragweed	Canada, US, and Northern Mexico	China	15.5
Argemone mexicana	Mexican prickly poppy	Mexico and Central America	Southeast Asia, India,Yemen & Syria	20
Bunias orientalis	Warty Cabbage	North America	China	20
Chromolaena odorata	Siam weed	America	Southeast Asia	30
Clidemia hirta	Koster's curse	Southern Mexico and Central America	Brunei, India, Japan and Singapore	10
Cytisus scoparius	Scotch Broom	Western and Central Europe	Northern Asia	7.5
Eichhornia crassipes	Water Hyacinth	South America	India, Indonesia, Malaysia & Philippines	20
Imperata cylinrica	Cogon grass	Africa and some parts in Asia	South and Western Asia	43
Ipomoea eberhardtii	Morning Glory	Mexico	Nepal	60
Lantana Camara	Red Sage	Central and South America	India and Souh-East Asia	50

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL370

Leucaena lueucocephala	Lead tree	Central and South America	Southeast Asia	25
Merremia boisiana	Wood Rose	South China	Vietnam	37
Mikania Micrantha	Bittervine	Central and South America	Southeast Asia	20
Mimosa pigra	Sensitive plant	South America	Southeast Asia, India and China	10
Myroxylon balsamum	Santos Mahogany	Southern Mexico, Peru and Brazil	Southern Sri Lanka and India	34
Opuntia Stricta	Erect Prickly Pear	Central Mexico	South and East Asia	7.5
Parthenium hysterophorus	Feverfew	Mexico, America, Trinidad and Argentina	India	13.5
Phyllostachys pubescens	Moso Bamboo	China	Japan	45
Pistia stratiotes	Water Lettuce	Africa and south America	Bangladesh, China, Thailand, Sri Lanka & India	50
Prosopis Juliflora	Mesquite	Mexico, South America and Caribbean	India	45
Tamarindus Indica	Tamarind	Madagascar	Japan and Taiwan	45
Ulex Europeaus	Common Gorse	Central and Western Europe	Southern and Tropical Asia	35

Table 1 shows the list of invasive plants geographical distribution across asia and their most common habitat particularly in western countries. It also displays the corresponding growth rates of the species.

- *Growth Rates*

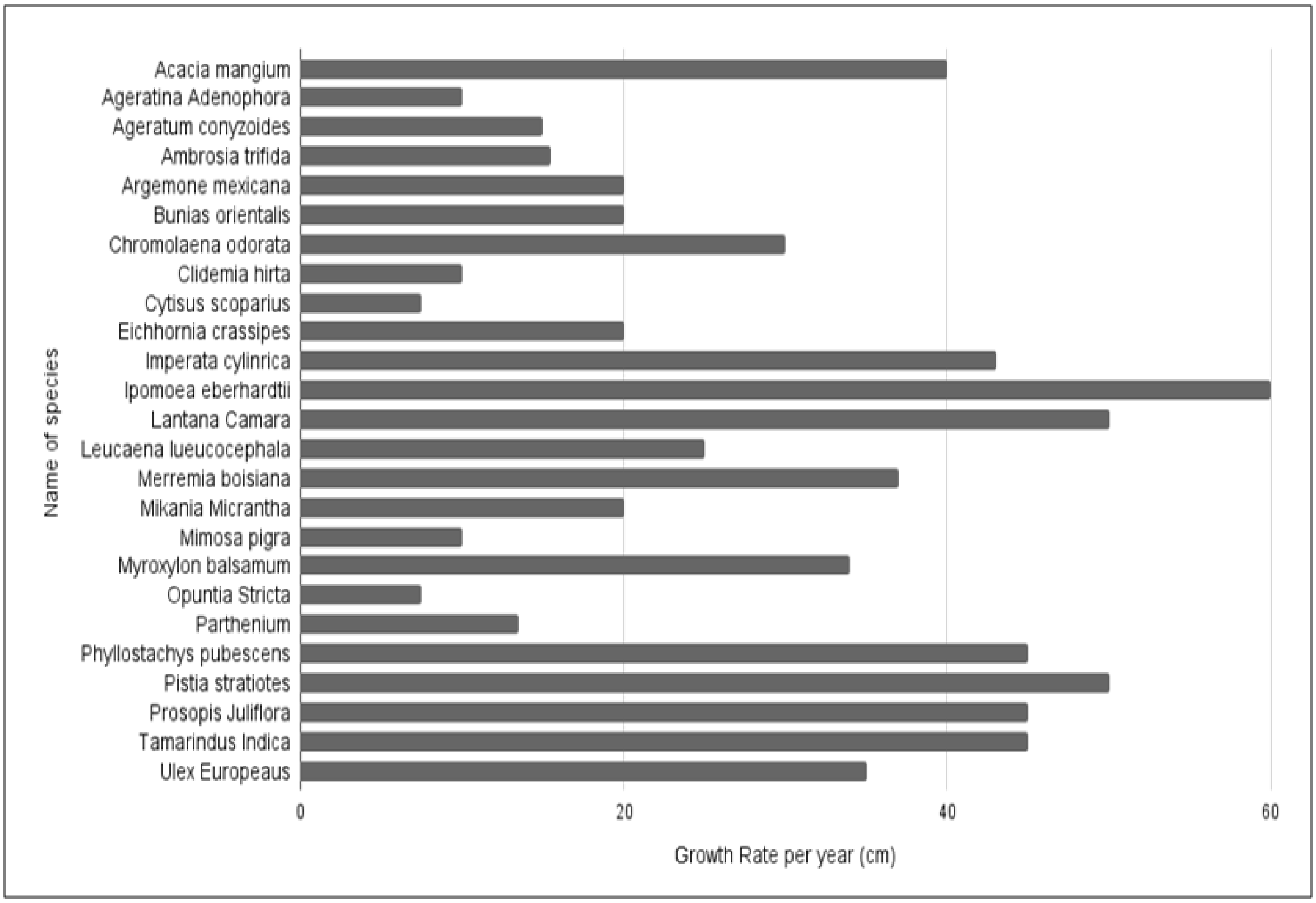

Fig 2 Growth Rate per year (cm) of Species

Figure 2 depicts the growth rate of the following species. Each species follows the geometric type of growth rate.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL370

➢ *Dispersal Rates and Mechanism*

Table 2 Dispersal Rates and Mechanisms

Species	Distance from the parent plant (km)	Primary Vector	Reference/Authors
Acacia mangium	0.5	Animal-Mediated, Wind-Dispersed	Dhamodaran & Chacko (2017)
Ageratina Adenophora	100	Wind-Dispersed, Water-Dispersed	Chuan et al. (2021)
Ageratum conyzoides	100	Wind-Dispersed, Water-Dispersed	Amarpeet et al. (2023)
Ambrosia trifida	20	Vegetative Propagation	Dong et al. (2020)
Argemone mexicana	5	Wind-Dispersed, Water-Dispersed	Namkeleja et al. (2018)
Bunias orientalis	0.002	Animal-Mediated	Corli et al. (2021)
Chromolaena odorata	200	Wind-Dispersed	Midori & Hisashi (2023)
Clidemia hirta	10	Animal-Mediated, Water-Dispersed	Cao et al. (2018)
Cytisus scoparius	0.005	Vegetative Propagation	Gudžinskas & Taura (2022)
Eichhornia crassipes	10	Water-Dispersed	Lekamge et al. (2020)
Imperata cylindrica	100	Vegetative Propagation, Wind-Dispersed	Muhammad (2020)
Ipomoea eberhardtii	14.75	Animal-Mediated, Water-Dispersed	Thi et al. (2019)
Lantana Camara	12	Vegetative Propagation, Water-Dispersed	Negi et al. (2019)
Leucaena leucocephala	9	Wind-Dispersed	Padma et al. (2020)
Merremia boisana	4.10	Animal-Mediated, Water-Dispersed	Thi et al. (2019)
Mikania Micrantha	100	Wind-Dispersed	Liu et al. (2020)
Mimosa pigra	9.76	Water-Dispersed, Human Activity	Amali & Florentine (2022)
Myroxylon balsamum	0.5	Animal-Mediated	Loayza-Cabezas et al. (2018)
Opuntia Stricta	1500	Animal-Mediated	Venter et al. (2022)
Parthenium hysterophorus	400	Wind-Dispersed	Bashar et al. (2023)
Phyllostachys pubescens	0.012	Vegetative Propagation	Xu et al. (2020)
Pistia stratiotes	2592	Water-Dispersed	Silva et al. (2020)
Prosopis Juliflora	203	Animal-Mediated	Patnaik et al. (2017)
Tamarindus Indica	0.0258	Animal-Mediated	Oyebamiji et al. (2018)
Ulex Europeaus	0.005	Explosion of pods	Juliana (2019)

Table 2 provides information on the dispersal rates and mechanisms of various plant species. Each species is associated with a specific distance from the parent plant and the primary method of dispersal, as documented by different researchers in various studies.

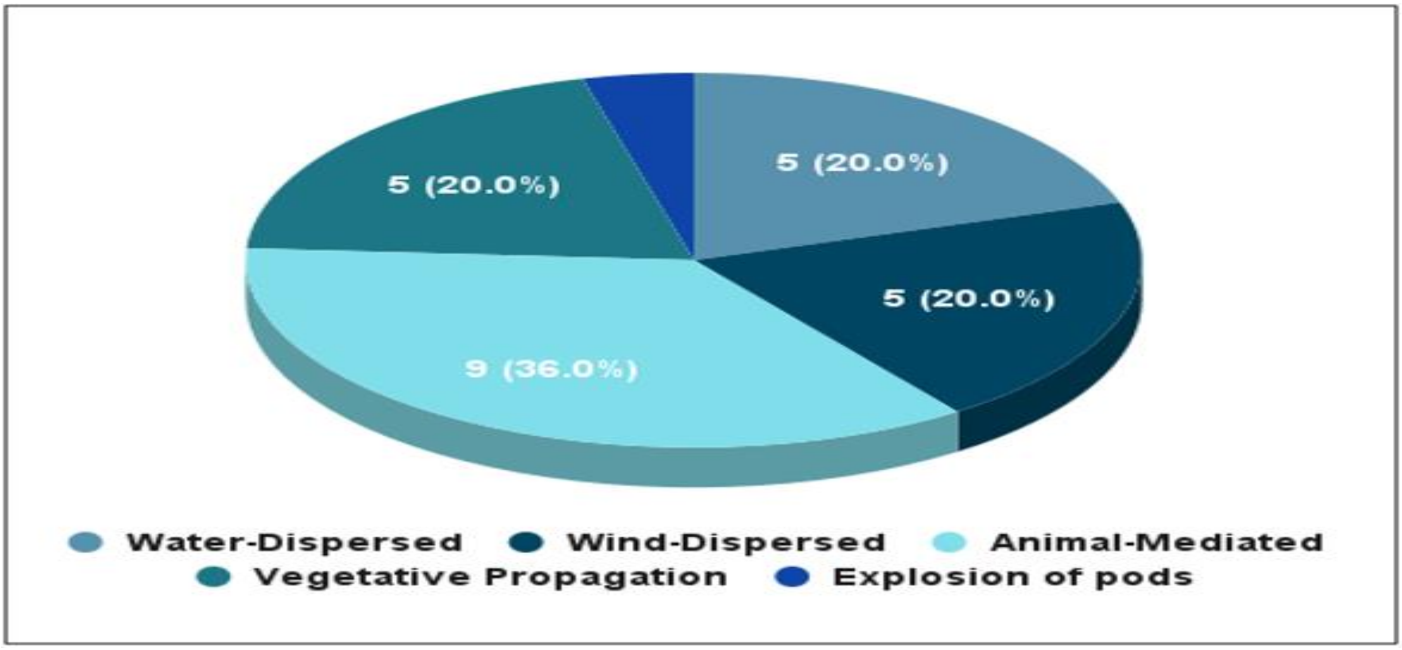

Fig 3 Count of Dispersal Mechanisms

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL370

Figure 3 represents the count and percentage of primary dispersal mechanisms for vegetation. The figure shows the prevalence of different dispersal methods, including explosion, vegetative propagation, wind, animals, humans, and water.

➤ *Allelochemicals and Allelopathic Effects*

Table 3 Allelochemicals are Present in each Invasive Plant Species.

Species	ALLELOCHEMICALS PRESENT	REFERENCE
Acacia mangium	Catechin, gallic acid, condensed tannins	Dhamodaran & Chacko (2017)
Ageratina adenophora	2-coumaric acid glucoside, eupatorin	Chuan et al. (2021)
Ageratum conyzoides	Alkyl resorcinol, pyrrolizidine alkaloid	Amarpeet et al. (2023)
Ambrosia trifida	Protocatechuic acid p- hydroxybenzoic acid, glyphosate	Dong et al. (2020)
Argemone mexicana	Cinnamic and benzoic acids, mimosine	Namkeleja et al. (2018)
Bunias orientalis	Glucosinolates, terpenes	Corli et al. (2021)
Chromolaena odorata	Pyrrolizidine alkaloid, chromomoric acid	Midori & Hisashi (2023)
Clidemia hirta	Kaempferol, coumarins, steroids, triterpenoids	Cao et al. (2018)
Cytisus scoparius	Sparteine, quercetin, condensed tannins, lupanene, gallic acids	Gudžinskas & Taura (2022)
Eichhornia crassipes	Juglone, 2-methoxy-1,4-napthtoquinone, gallic acid,limonene, sorgoleone.	Lekamge et al. (2020)
Imperata cylinrica	Imperactacylin A, imperanine	Muhammad (2020)
Ipomoea eberhardtii	Caffeic acid, ferulic acid, and p-coumaric acid, Terpenoids, and carotenoids	Thi et al. (2019)
Lantana camara	Lantadene A&B luteolin, quercetin, gallic acid, gallotannins	Negi et al. (2019)
Leucaena lueucocephala	Mimosine and quercetin	Padma et al. (2020)
Merremia boisiana	Phenolic compounds, Terpenoids, and alkaloids	Thi et al. (2019)
Mikania micrantha	Sesquiterpene lactones, caffeic acids	Liu et al. (2020)
Mimosa pigra	Phytotoxin mimosine,catechin, leucenol, piperidine alkaloids.	Amali & Florentine (2022)
Myroxylon balsamum	caffeic acid, chlorogenic acid, ferulic acid, myricetin, and quercetin	Loayza-Cabezas et al. (2018)
Opuntia stricta	Opuntiol, ascorbate, carotenoids, betalains, and phenolic acids	Venter et al. (2022)
Parthenium hysterophorus	Parthenin, ambrosin, caffeic acids, chlorogenic acid, ferulic acid	Bashar et al. (2023)
Phyllostachys pubescens	Quercetin, kaempferol, gallotannins, guaiacyl lignin	Xu et al. (2020)
Pistia stratiotes	Gallic acid, kaempferol	Silva et al. (2020)
Prosopis juliflora	Quercetin, kaempferol, juliprosopine	Patnaik et al. (2017)
Tamarindus indica	Gallotannins, catechin, glycosides.	Oyebamiji et al. (2018)
Ulex europeaus	Quinolizidine alkaloids, methanolic, eugenol, verbenone, terpinen-4-ol	Juliana (2019)

Table 3 presents the allelopathy found in the invasive plant species through the production and release of allelochemicals signaling chemicals to suppress competing plant species.

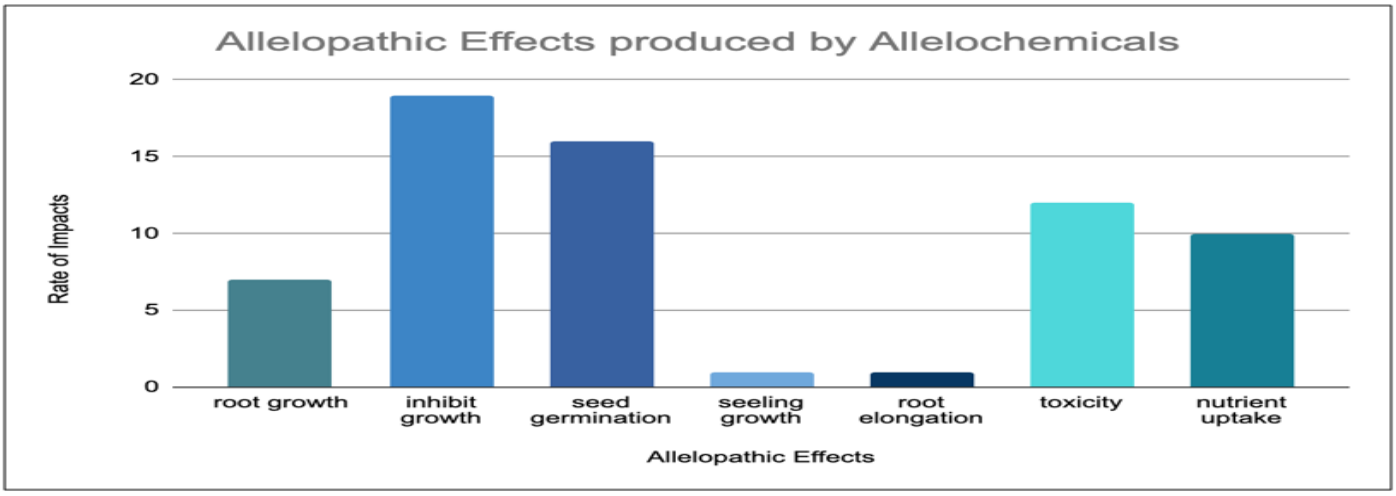

Fig 4 Allelopathic Effects of Invasive plants

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL370

Figure 4 highlights the significant effects of allelochemicals released in the environment leading to their successful invasion.

- *Implemented Management Approaches*

Table 4 Implemented Management Approaches

Species name	Awareness	Biological control	Competition	Chemicals	Drivers	Physical	Uses
Ageratina adenophora	✓	✓	✓	✓		✓	✓
Acacia mangium	✓	✓	✓	✓			✓
Ageratum conyzoides		✓		✓		✓	
Ambrosia trifida	✓	✓	✓	✓	✓	✓	✓
Argemone mexicana		✓	✓	✓		✓	✓
Bunias orientalis	✓	✓	✓	✓	✓		✓
Chromolaena odorata		✓	✓	✓		✓	✓
Clidemia hirta	✓	✓	✓	✓	✓	✓	✓
Cytisus scoparius	✓	✓	✓	✓	✓	✓	✓
Eichhornia crassipes		✓		✓		✓	✓
Imperata cylinrica			✓	✓	✓	✓	✓
Ipomoea eberhardtii		✓	✓	✓	✓		✓
Lantana camara	✓	✓		✓	✓	✓	✓
Leucaena lueucocephala	✓	✓		✓		✓	✓
Merremia boisiana	✓	✓		✓		✓	✓
Mikania micrantha	✓	✓		✓		✓	
Mimosa pigra			✓	✓		✓	
Myroxylon balsamum	✓	✓	✓	✓	✓	✓	✓
Opuntia stricta		✓					
Parthenium hysterophorus		✓	✓	✓		✓	✓
Phyllostachys pubescens	✓	✓	✓	✓	✓		✓
Pistia stratiotes			✓	✓		✓	✓
Prosopis juliflora				✓	✓	✓	
Tamarindus indica	✓	✓	✓	✓	✓	✓	✓
Ulex europeaus		✓	✓	✓	✓	✓	

Table 4 represents in the research article this focus the implemented management approaches of invasive plant species across Asia. These are the list of invasive plant species that have a classification of Public awareness (by informing local people about the impacts), biological control, competition (removing invasive species by competing with native species), drivers (by knowing factors that import invasive species), physical (manual removal), and uses (using plants as green manure or for bedding of livestock).

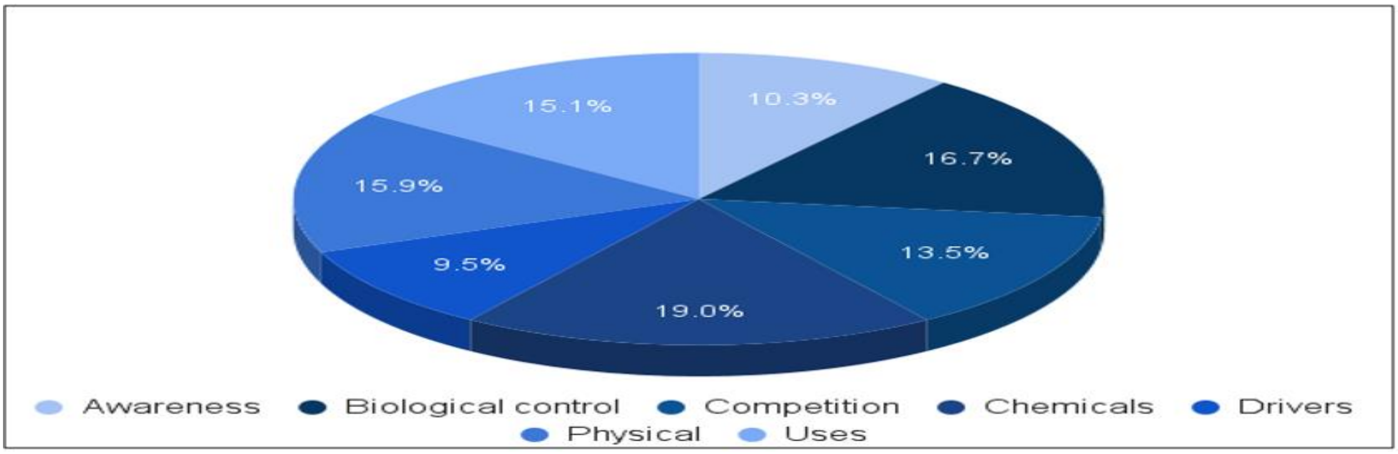

Fig 5 Percentage of Management Approaches Used

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL370

Figure 5 shows the percentage of implemented management approaches which demonstrates the following chart. The invasive plant species of awareness has 10.3 percent management approaches, The biological control rates at 16.7 percent approaches, in competition that has 13.5 percent approaches, chemicals figure at 19.0 percent of management approaches, drivers rates at 9.5 percent approaches, physical reaches at 15.9 percent of its approaches, finally the uses were takes at 15.1 percent implemented management approaches. This classification of plant species helps identify responsible factors to manage invasive species.

➢ *Control Measures*

Table 5 Control Measures of Invasive Plant Species in Different Dynamic Processes

	Control measures		
Plants species	**Physical**	**Chemical**	**Mechanical**
Acacia mangium		✓	✓
Ageratina adenophora		✓	
Ageratum conyzoides		✓	
Ambrosia trifida		✓	
Argemone mexicana		✓	✓
Bunias orientalis	✓	✓	
Chromolaena odorata	✓		✓
Clidemia hirta	✓		✓
Cytisus scoparius	✓	✓	
Eichhornia crassipes	✓	✓	✓
Imperata cylinrica	✓		
Ipomoea eberhardtii	✓	✓	
Lantana camara	✓	✓	✓
Leucaena lueucocephala	✓	✓	
Merremia boisiana	✓	✓	
Mikania micrantha		✓	✓
Mimosa pigra	✓	✓	
Myroxylon balsamum	✓	✓	✓
Opuntia stricta	✓	✓	
Parthenium hysterophorus		✓	✓
Phyllostachys pubescens		✓	
Pistia stratiotes	✓	✓	
Prosopis juliflora		✓	✓
Tamarindus indica	✓	✓	
Ulex europeaus	✓	✓	✓

Table 5 shows the control measures that have significant impacts on the environment. The check marks represent the presence of each invasive plants species which classifies in three categories. Physical, Chemical and Mechanical. Physical control measures which specify cutting trees, leaf removal, hand pulling and many other physical activities. Chemical control measures include the uses of herbicides like metsulfuron-methyl, glyphosate, pendimethalin and other sources of chemicals. Mechanical control measures illustrate the control machine that includes tractors that reduce the damage of vegetation in that area. Overall, the attributes of these invasive plant species are vital for maintaining ecological balance and protecting biodiversity. Invasive plant species often grow rapidly and spread aggressively, outcompeting native flora and leading to a reduction in biodiversity.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL370

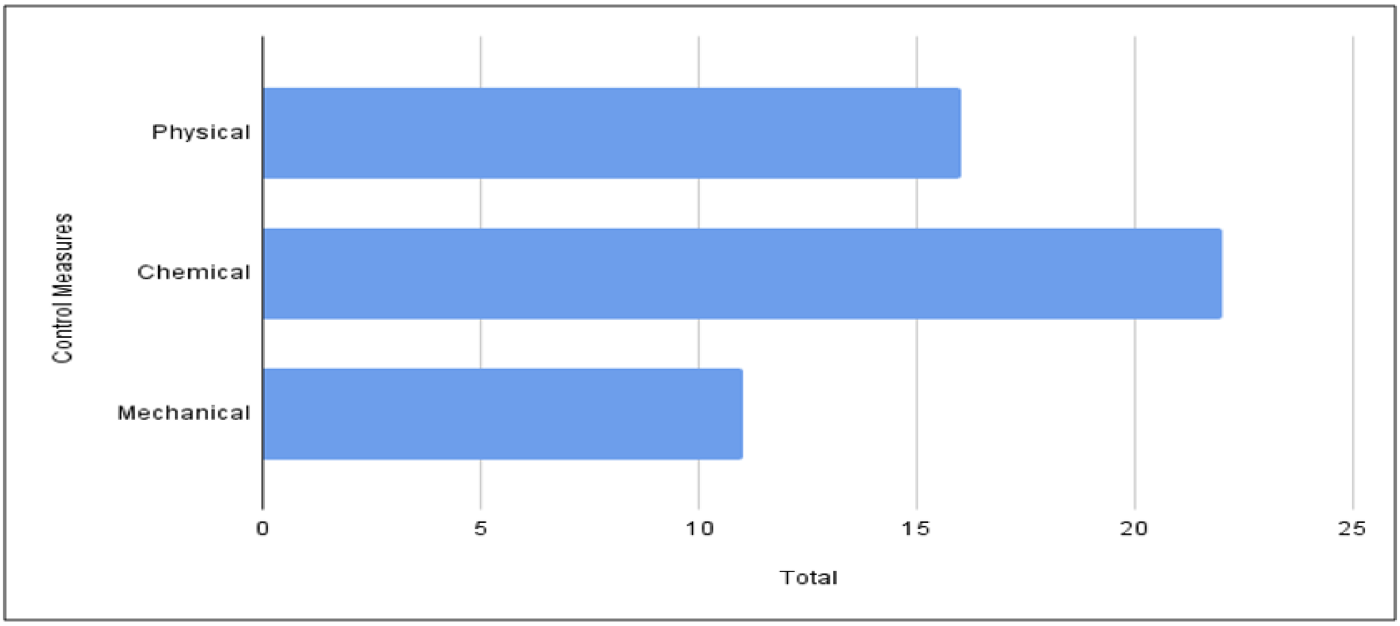

Fig 6 Control Measures used in the Invasive Species

Figure 6 highlights the numerical count of control measures used in the invasive plants species. Physical control measures have numerical value of 16 invasive plant species present in the table shown above. Chemical control measures have numerical value of 22 invasive plants species presence to its impact. Lastly, mechanical control measures have numerical value of 11 invasive plants species presence. Overall, the total attributes of physical, chemical, and mechanical control measures have 49 total counts in the category. Each strategy has advantages and disadvantages, but when used together, they can achieve long-term management while preserving ecosystem health and diversity.

IV. DISCUSSION

This paper assesses the factors that influence the performance of invasive plant species under competition-free environment. The identification of the different levels of reproduction, dispersal, and growth rates denotes the ability of exotic plants to persist in any environment causing ecological imbalance by the significant increase of biotic occupation.

- *List of Invasive Plant Species Introduced Across Asia*

The following species shown in Table 1 is composed of grasses such as *Imperata cylindrica* and *phyllostachys pubescens*; shrubs such as *prosopis juliflora*, *cytisus scoparius*, *Clidemia hirta*, and *Chromolaena odorata*; trees such as *Tamarindus Indica*, and *Acacia mangium*; and aquatic plants such as *eichhornia crassipes* and *Pistia stratiotes*. A majority of these species are flowering plants, which might be an advantage to them to propagate. These species mostly originate from the Americas, specifically in Canada, United States, Mexico, Brazil, Peru, Argentina, and Caribbean nations in Central America such as Trinidad and Tobago. There are also species that originate in Europe, Africa, Oceania, and within Asia as well. The regional distribution for these plants is shown to spread out across Asia but are less common in Northern Asia. Most of these species like *Ageratina Adenophora, Pistia stratiotes, Mimosa pigra* ,and *Ageratum conyzoides*,are prevalent in both South and Southeast Asia.

- *Growth Rates*

Reproductive success in the given data, several species exhibit relatively high reproductive success, such as Eichhornia crassipes, Phyllostachys pubescens, Prosopis Juliflora, Tamarindus Indica, Lantana Camara, Ipomoea eberhardtii, and Pistia stratiotes, with growth rates ranging from 20 to 60 cm per year.

These species are likely to produce a significant number of seeds or propagules, which enhances their ability to disperse and establish in new habitats. High reproductive success can lead to the rapid colonization of available resources and the outcompeting of native species. It allows invaders to quickly establish self-sustaining populations, leading to successful invasions.

Species with fast growth rates can outcompete native species for limited resources such as light, nutrients, and space. In the given data, species like Phyllostachys pubescens, Prosopis Juliflora, Tamarindus Indica, Lantana Camara, Pistia stratiotes, Acacia mangium, and Imperata cylindrica exhibit relatively high growth rates ranging from 40 to 60 cm per year.

These fast-growing species can quickly establish dominance over native vegetation, forming dense stands and altering ecosystem dynamics. Rapid growth allows invaders to exploit available resources efficiently and create conditions unfavorable for the survival of native species. As a result, their growth success contributes significantly to invasion success.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL370

Comparing the species listed, it is evident that those with higher growth rates and reproductive success tend to be more successful invaders. Species like Phyllostachys pubescens, Prosopis Juliflora, Tamarindus Indica, Lantana Camara, Ipomoea eberhardtii, and Pistia stratiotes exhibit both high growth rates and reproductive success. These species have successfully invaded various regions.

On the other hand, species with lower growth rates and reproductive success, such as Cytisus scoparius, Opuntia Stricta, Ageratina Adenophora, Mimosa pigra, and Argemone mexicana, are likely to be less successful invaders. Although they may still colonize certain areas, their slower growth and lower reproductive output limit their ability to establish and spread as extensively as the more successful invaders.

- *Dispersal Mechanisms and their Efficacy*

The dispersal mechanisms of invasive plants are primarily driven by wind and water, which account for 55.6% of the total dispersal. Wind is a significant dispersal vector for many invasive plant species with 25% of the total dispersal. Wind can disperse seeds, fruits, and other plant parts over long distances, often exceeding hundreds of kilometers. Wind-dispersed diaspores can persist over winter and form new plants at a density of about 2 plants per m^2 at 500 m away from the source (Li & Shen, 2020). Water is another important dispersal vector for invasive plants with 30.6% total dispersal. Rivers, in particular, have been found to be a significant vector for the spread of invasive plant species. For instance, the invasive plant species spread rapidly along the Yangtze River in China, with model predictions suggesting that the species will quickly spread along the river and colonize large areas within a few years (Gippet et al., 2017).

Animals with 25% total dispersal, are essential in dispersing seeds of invasive plant species. Frugivores, such as birds and mammals, consume fruits and seeds, and then deposit the seeds in new locations, often with a higher probability of germination. Frugivorous birds have been found to disperse seeds of invasive shrubs, with germination success of both depulped and ingested seeds being high (> 80%). Human activities, such as trade, transportation, and tourism, are crucial contributors to the spread of invasive plant species. Human-mediated dispersal can occur through the intentional or unintentional movement of plant materials, such as seeds, fruits, and cuttings (Juncosa-Polzella et al., 2023). Vegetation also has the potential to aid in the spread of invasive plant species, accounting for 5.6% of total dispersal. Invasive shrubs can act as shelters for versatile consumers, enabling them to carry and scatter seeds of indigenous plants (Malo et al., 2021).

Successful invaders, characterized by their ability to rapidly spread and establish populations in new habitats, often exhibit efficient dispersal mechanisms that contribute to their success. Species like *Parthenium hysterophorus*, with a dispersal distance of 400 km through wind dispersal as reported by Bashar et al. (2023), and *Pistia stratiotes*, dispersing over 2592 km solely through water dispersal according to Silva et al. (2020), are case of successful invaders that utilize effective dispersal strategies to colonize vast areas. These species demonstrate the importance of long-distance dispersal mechanisms in facilitating their invasive success. On the other hand, less successful invaders may exhibit limitations in their dispersal rates and mechanisms, hindering their ability to establish widespread populations. Species like *Bunias orientalis*, which disperses over a minimal distance of 0.002 km through animals as noted by Corli et al. (2021), and *Ulex Europeaus*, with a dispersal distance of 0.005 km through the explosion of pods according to Juliana (2019), may face challenges in spreading efficiently across diverse landscapes. These species may struggle to compete with more successful invaders that possess greater dispersal capabilities. The analysis also uncovers how particular dispersal mechanisms influence the success of invaders. Species like *Ambrosia trifida* and *Leucaena leucocephala*, with moderate dispersal rates through vegetation and wind dispersal respectively, may fall in between the spectrum of successful and less successful invaders, as documented by Dong et al. (2020) and Padma et al. (2020). The effectiveness of dispersal mechanisms in facilitating rapid spread is evident in the varying success rates of invasive species in colonizing new territories.

- *Allelochemicals and Allelopathic Effects*

The "novel weapons hypothesis" states that detrimental plant biochemicals, such as the exudate from allelopathic antimicrobial roots, which directly impede plant development and soil microbial activity, are essential to the success of invading species. Nevertheless, little is known about how invasive plants use allelopathy to combine their direct and soil-mediated effects (Qu et al., 2021). The allelopathy inhibits the ability of plants from germinating and suppressing their growth in its vicinity to further propagate through releasing secondary metabolites, which are known as allelochemicals. A diverse range of phenotypic methods are employed by invasive species to establish themselves in new habitats leading to their successful occupation exterminating the native ones. According to a recent meta-analysis on the direct allelopathic impacts on plants, neighboring plants' performance was, on average, 25% lower (Zhang et al., 2020). But anti-microbial allelopathic substances can potentially change the availability of nutrients in the soil (Zhang et al., 2019) or even kill soil microorganisms directly, upsetting plant-microbial mutualisms which are essential for plant resource acquisition. Some of the major allelochemical compounds that includes flavanoids, phenols, tannins, alkaloids, parthenin and lactones which are released in the environment may offer significant benefits in individual specie but poses a threat to the biological process of native ones. Allelopathic compounds help invasive species outcompete native species by modifying seed germination, inhibiting seedling growth, and interfering with nutrient cycling. These alterations in the ecosystem, driven by allelochemicals, give invasive plants a growth advantage, leading to their successful establishment. Plants such as *Lantana camara*, *Mikania micrantha, Opuntia stricta* and *Eichhornia crassipes* have shown a wide geographical distribution in Asia particularly in southern and eastern part interpreting their competitive advantage over native species.

The most substantial influence of the chemical produced by these species hinders the germination of seeds interfering the activity and expression of enzymes disrupting the enzymatic processes necessary for a plant's growth and development.

➢ *Management*

Despite a recent increase in the number of published papers, research on the control of invasive plants in South Asia remains limited. The most popular methods for removing invasive species in South Asian countries are chemical, physical, and mechanical (Raj et al., 2018). There have been initiatives to manage invasive species through physical eradication with the assistance of residents (Sullivan and York 2021), which is labor intensive. For example, the management of Pontederia crassipes through its biomass for various uses has been tried but failed due to a lack of consistent funding (Patel 2012). Unfortunately, biological control is still in its early stages and underdeveloped in South Asia due to the high initial cost and lengthy screening process. However, certain biological control agents for Ageratina adenophora, Chromolaena odorata, Lantana camara, Mikania micrantha, Parthenium hysterophorus, and Pontederia crassipes have been introduced into South Asia (Dhileepan and Senaratne 2009; Poudel et al. 2020; Shrestha et al. 2022). In Papua New Guinea, the gall fly Cecidochares connexa was discovered to successfully suppress the populations of invasive Chromolaena odorata (Day et al. 2013). In South Africa and some neighboring countries, the floral galling mite Aceria lantanae reduced Lantana camara flower production by up to 97% (Simelane et al. 2021). Furthermore, absence of natural enemies, physical disturbance, and open forest canopies all contribute to the survival of invasive species (Mandal and Joshi 2014). Passenger air travel is regarded as an introduction vector in South Asia (Early et al., 2016). Identifying the primary motivations and paths of plant invasions is critical for effective management. Lantana camara is a ubiquitous species that is difficult to eliminate using mechanical, chemical, and biological means (Love et al. 2009). In South Asia, the elimination of L. Camara is practically impossible, but its harmful effects can be mitigated by control.

V. CONCLUSIONS

Though species that are discussed are mostly equally spread across Asia, its especially prevalent in South and Southeast Asia. We can conclude that these species easily propagate in tropical regions such as the Philippines, Indonesia, Malaysia, Vietnam, Thailand, India, and Bangladesh. The country of origin of these species mostly come from the Americas, which similarly booming with biodiversity compared to Asia. A likely hypothesis of this is that the competitive ecosystem from the country of origin made it easier to spread in less competitive environments. The growth rates vary, with the lowest being 7.5 cm per year and the highest being 60 cm per year. Most of these species' growth rates fall in ranges of 20 to 40 cm per year.

The dispersal rates of these species have a wide range, falling between 0.002 km from the parent plant being the lowest, and 2592 km from the parent plant being the highest. The species that averages around 100 km from the parent plant relies on wind dispersion. Most of these species rely on animal mediated and wind dispersion as most of the species listed are flowering plants, which utilizes these methods to cross-pollinate. Most of the species that utilizes water dispersion ranges from 10 to 100 km from the parent plant. An outlier from these species that use water dispersion as a means of spreading, is the *Pistia stratiotes*, or the Water Lettuce which relies on stolon that are used as nodes from the parent plant.

Allelochemicals have different uses for the plant. But most of these species use these allelochemicals to inhibit growth and seed gemination. This allows the plant to reproduce and multiply faster. Nutrient uptake and root growth are the allelopathic effect that is also highly prevalent among these plants as they would easily take up resources to make them reproduce faster. These species likely evolved to compete with other plants in their environment, and easily take up resources to spread faster. Toxicity is another allelopathic effect that is quite notable. These are just used as defense mechanisms to defend itself from the environment.

The most implemented control measures for these invasive species are the physical, biological, and chemical means of control. Physical means of control are especially cheap to do as it just simply means removing the plant by uprooting or removing the plant by other physical means. Using biological means is quite cheap to use as well, as it utilizes the natural enemies of these plants, like insects, to control the population. There is also the chemical means of control, which uses chemicals like herbicides to kill the plant population. All these control measures are generally cheap, or at least commercially viable to use.

REFERENCES

[1]. Bashar, H. M., Juraimi, A. S., Ahmad-Hamdani, M. S., Uddin, M. K., Asib, N., Anwar, M. P., Rahaman, F., Haque, M. A., & Hossain, A. (2023). Evaluation of allelopathic effects of Parthenium hysterophorus L. methanolic extracts on some selected plants and weeds. *PLOS ONE, 18*(1), e0280159. https://doi.org/10.1371/journal.pone.0280159

[2]. Batish, D., Singh, H., Kaur, S., & Kohli, R. (2013). Novel weapon hypothesis for the successful establishment of invasive plants in alien environments. In CRC Press eBooks (pp. 19–28). https://doi.org/10.1201/b13865-4

[3]. Bhatta, S., Shrestha, B. B., & Pyšek, P. (2023). Invasive alien plants in South Asia: Impacts and management. NeoBiota, 88, 135–167. https://doi.org/10.3897/neobiota.88.10411

[4]. Chengxu, W., Mingxing, Z., Xuhui, C., & Bo, Q. (2011). Review on allelopathy of exotic invasive plants. Procedia Engineering, 18, 240–246. https://doi.org/10.1016/j.proeng.2011.11.038

[5]. Corli, A., Walter, J., & Sheppard, C. S. (2021). Invasion Success of Bunias orientalis (Warty Cabbage) in Grasslands: A Mesocosm Experiment on the Role of Hydrological Stress and Disturbance. *Frontiers in Ecology and Evolution*, *9*. https://doi.org/10.3389/fevo.2021.625587

[6]. Cui, C., Wang, Z., Su, Y., & Wang, T. (2021). New insight into the rapid growth of the Mikania micrantha stem based on DIA proteomic and RNA-Seq analysis. Journal of Proteomics, 236, 104126. https://doi.org/10.1016/j.jprot.2021.104126

[7]. Dong, H., Liu, T., Liu, Z., & Song, Z. (2020). Fate of the soil seed bank of giant ragweed and its significance in preventing and controlling its invasion in grasslands. *Ecology and Evolution*, *10*(11), 4854–4866. https://doi.org/10.1002/ece3.6238

[8]. Gudžinskas, Z., & Taura, L. (2022). Do Reproductive Traits of Invasive Populations of Scotch Broom, Cytisus scoparius (Fabaceae), Outperform Native Populations? *Plants*, *11*(16), 2158. https://doi.org/10.3390/plants11162158

[9]. Juliana, P. Y. (2019). *The invasive species Ulex europaeus modifies its seeds morphology and germination pattern as it moves up along an elevation gradient*. Repositorio Institucional Séneca. https://repositorio.uniandes.edu.co/items/5f5803a7-de53-441d-9931-b48b5c7ac47f

[10]. Juncosa-Polzella, A. S., Tecco, P. A., & Vergara-Tabares, D. L. (2023). Seed dispersal of a fleshy-fruited invasive shrub is affected by changes in the frugivorous bird assemblage along an elevational gradient. *Austral Ecology*, *48*(8), 1797-1814. https://doi.org/10.1111/aec.13423

[11]. Kato-Noguchi, H., & Kato, M. (2023). Evolution of the Secondary Metabolites in Invasive Plant Species Chromolaena odorata for the Defense and Allelopathic Functions. Plants, 12(3), 521. https://doi.org/10.3390/plants12030521

[12]. Lekamge, M., Wijeyaratne, M., & Dahanayaka, D. (2020). Water quality parameters contributing to the invasion of water Hyacinth (Eichhornia crassipes) in the Anawilundawa reservoir in Sri Lanka. *Sri Lanka Journal of Aquatic Sciences*, *25*(1), 9-17. https://doi.org/10.4038/sljas.v25i1.7572

[13]. Li, Y., & Shen, Z. (2020). Roles of dispersal limit and environmental filtering in shaping the spatiotemporal patterns of invasive alien plant diversity in China. *Frontiers in Ecology and Evolution*, *8*. https://doi.org/10.3389/fevo.2020.544670

[14]. Liu, B., Yan, J., Li, W., Yin, L., Li, P., Yu, H., Xing, L., Cai, M., Wang, H., Zhao, M., Zheng, J., Sun, F., Wang, Z., Jiang, Z., Ou, Q., Li, S., Qu, L., Zhang, Q., Zheng, Y., . . . Wan, F. (2020). The Mikania micrantha genome provides insights into the molecular mechanism of rapid growth. *Nature Communications*, *11*(1). https://doi.org/10.1038/s41467-019-13926-4

[15]. Loayza-Cabezas, S., Rodriguez-Trejo, D. A., Hernández-Acosta, E., & Suárez, J. A. (2018). EFFECT OF LIGHT, TEMPERATURE AND SCARIFICATION ON THE GERMINATIVE CAPACITY AND INITIAL GROWTH OF Myroxylon balsamum (L.) HARMS. *Revista Caatinga*, *31*(2), 415–423. https://doi.org/10.1590/1983-21252018v31n218rc

[16]. Malo, A. F., Taylor, A., & Díaz, M. (2021). Native seed dispersal by rodents is negatively influenced by an invasive shrub. *Animal Biodiversity and Conservation*, 53-67. https://doi.org/10.32800/abc.2022.45.0053

[17]. Moshia, M. E., & Newete, S. W. (2018). Mexican poppy (Argemone mexicana) control in cornfield using deep learning neural networks: a perspective. Acta Agriculturæ Scandinavica. Section B, Soil and Plant Science, 69(3), 228–234. https://doi.org/10.1080/09064710.2018.1536225

[18]. Namkeleja, H. S., Tarimo, M. T. C., & Ndakidemi, P. A. (2014). Allelopathic Effects of <i>Argemone mexicana</i> to Growth of Native Plant Species. American Journal of Plant Sciences, 05(09), 1336–1344. https://doi.org/10.4236/ajps.2014.59147

[19]. Negi, G. C. S., Sharma, S., Vishvakarma, S. C., Samant, S. S., Maikhuri, R. K., Prasad, R. C., & Palni, L. M. S. (2019). Ecology and Use of Lantana camara in India. *The Botanical Review*, *85*(2), 109–130.https://doi.org/10.1007/s12229-019-09209-8

[20]. Patnaik, P., Abrasi, T., and Abrasi, S. A. (2017). Prosopis juliflora Blessing and bane /links/5a6971bda6fdcccd01a1a7ff/Prosopis-Prosopis-juliflora-Blessing-and-bane.pdf https://www.researchgate.net/profile/S-A-Abbasi/publication/322682224

[21]. Rai, P. K., & Singh, J. (2020). Invasive alien plant species: Their impact on environment, ecosystem services and human health. Ecological Indicators, 111, 106020. https://doi.org/10.1016/j.ecolind.2019.106020

[22]. Sharma, P., Kaur, A., Batish, D. R., Kaur, S., & Chauhan, B. S. (2022). Critical Insights Into the Ecological and Invasive Attributes of Leucaena leucocephala, a Tropical Agroforestry Species. Frontiers in Agronomy, 4. https://doi.org/10.3389/fagro.2022.890992

[23]. Silva, J. S., Costa, A. S., & Silva, M. S. (2020). Ecological and Chemical Characteristics of Pistia stratiotes: A Study on Growth, Reproduction, Dispersal, and Allelochemicals. *Journal of Aquatic Plant Management*, *58*, 1-11. https://doi.org/10.1016/j.japm.2020.02.001

[24]. Van Hieu Pham, P. T. K. T. V. T. B. H. N. (2021). Assessment of the current distribution, dispersal trends and impacts of invasive species in Bana - Nui Chua Nature Reserve, Vietnam. *Tạp Chí Khoa Học Và Công Nghệ*, 6–11. https://doi.org/10.31130/jst-ud2021-437

[25]. Venter, N., Cowie, B. W., & Byrne, M. J. (2022). Prospects for the biological control of the invasive cactus, Opuntia stricta using Dactylopius opuntiae, under conditions of rising atmospheric CO2. *Biological Control*, *176*, 105095. https://doi.org/10.1016/j.biocontrol.2022.105095

[26]. Yuan, C., Wang, Q., Chen, Y., Zhang, L., Tan, L., Fu, R., Yang, J., Li, Y., Liu, M., & Compton, S. G. (2021). Impacts of a biocontrol agent on invasive Ageratina adenophora in Southwest China: Friend or foe? Biological Control, 152, 104471. https://doi.org/10.1016/j.biocontrol.2020.104471