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Assessing The Sustainability of Chemical Control Methods in Pest Management: A Review of Carrying Capacity and Pesticide Use

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Abstract

In the present study, the harmful effect of Partheniumhysterophoruson soil, humans, crops and animals has been studied. Apart from that, it has also been understood from the study that despite the negative effect of the weed it has some positive effects also including antidiabetic, antioxidant, antitumor and antimicrobial activities. The study's main objective is to look into Parthenium hysterophorus's damaging effects on farmland. In addition, another objective is to assess the effectiveness of chemical pest management for P. hysterophorus and find the harmful effects or sustainability of P. hysterophorus pesticide use on the environment.The chemical constituents of the weed help to understand the cause and effect of the weed on humans. On the other hand, the chemical control method of P.hysterophorushas been studied along with the concept of carrying capacity. The research questions of the present study are whether the effect of P. hysterophorus on crop production is negative or positive. Additionally, what should be the chemical control methods and what are the effect and level of sustainability of the chemical control method of herbicides have been focused on in the research questions. The null hypothesis of the present research has shown that there is no relation between the level of weed and the amount of crop production. On the other hand, alternative hypotheses have stated that P. hysterophoruscan reduce the amount of crop in the field. This research utilized an experimental approach to investigate the impact of P. hysterophorus on crop yields. All of this study has been carried out by strictly adhering to a replacement experimental design. The study resulted in the negative impact of P. hysterophorus on crop production. It has also been found that glyphosate, 2,4-D, atrazine has played a positive role in the chemical control of the weed. Lastly, the negative impact of those herbicides by affecting non-target organisms, contamination of water resources and health effects has also been found.

Keywords: *P. hysterophorus, chemical weed management, environmental sustainability, carrying capacity*

1. Introduction

Research background

Over thousands of years, civilizations that had less knowledge than today's, have used chemical pest control methods. The Sumerians found that the use of sulfur to kill insects has been quite efficient. Chemical pest control techniques are still widely used nowadays, and even though pesticides often cause serious health problems, chemical substances are produced and sold in huge volumes across the world.

"Insecticides", "fungicides", "herbicides", "rodenticides", "molluscicides", "nematicides", growth regulators for plants, and many more are included in this broad category of pesticides. Among these, "organochlorine (OC) pesticides" became restricted or prohibited after the 1960s in most of the advanced nations, despite their successful use in controlling a wide range of illnesses like malaria and typhus. Pest control and agricultural output has been greatly aided by the advent of "herbicides and fungicides" in "the 1970s and 1980s" (Baker et al, 2020. p.104095). Along with that, "other synthetic insecticides such as" "organophosphate (OP) insecticides in the 1960s", "carbamates in the 1970s", and "pyrethroids in the 1980s" are also aided. An effective pesticide can kill its target pests yet does not affect any other species, including humans. The use and abuse of pesticides is becoming controversial nowadays.

In addition, to its native range in "North America", "South America", and the "West Indies", the toxic plant Parthenium hysterophorus L. (Asteraceae) can be discovered in many other places all over the globe. This noxious invasive species are among the most damaging weeds known. It is a significant threat to biodiversity and causes severe difficulties for both humans and animals, including "dermatitis", "asthma", and "bronchitis", as well as agricultural losses (Hubert et al. 2021, p.265). It is generally accepted that the seeds of this weed have been introduced to India with grains that have beenimported from the United States as part of the PL 480 scheme, also known as the "Food for Peace" food support program of the United States government. Since, they have spread like wildfire to well almost every state in India, in where they have grown into a native-born weed.

In India, crop production reductions varied from 6.5% to 55.0%, with the greatest losses seen in "arugula" (55%) and "sunflower" (52.5%). Losses in output may be caused by intervention (Upadhayay et al. 2020, p.87). In addition, P. hysterophorus is toxic to cattle, horses, and other creatures because of the presence of **phenolic metabolites**.

Figure 1: Conceptualization of the overall research

(Source: Self-developed)

The main aim of the present research is to assess the sustainability of chemical control methods in pest management. The research objectives of the study are to understand the negative impact of P. hysterophorus on agriculture, to evaluate the chemical control of pest management of P. hysterophorus and to found the negative impact or sustainability of the chemical control of P. hysterophorus on the environment

In 2019, the global use of pesticide consumption has been recorded as 4.19 MMT related to China consuming more than any other country involved ("1.76 MMT"). "Insecticides (29.5%)", "fungicides (17.5%)", and "herbicides (47.5%, d tons)" has been categorized in "Brazil (377 thousand tons)", and "Argentina (204 thousand tons)" (Singh et al. 2020, p.121525). There are numerous different methods for categorizing pesticides. Method of entry, chemical composition, and the species that are intended to eradicate are the most common criteria used to classify pesticides. However, WHO and the "Globally Harmonized System (GHS)" emphasized public health by classifying pesticides according to their toxicity or harmful effects.

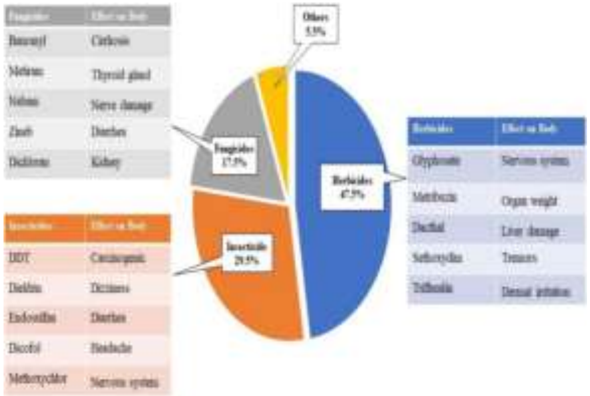

Figure 2: Pesticides distribution in percentage

(Source: Lykogianni et al. 2021, p.148625)

Harmful effects of P. hysterophorus on human, soil, crop and animal

There are several impacts of P. hysterophorus on different aspects such as it has impacted human health. This particular weed generally impacts various allergic diseases, asthma, skin rashes, swelling and itching in the nasal area and in the mouth. Wedding manually in fields overgrown with Parthenium might lead to skin illnesses, and allergies to the species have been linked to plasmodium infection fever (Lykogianni et al. 2021, p.14862). Long-term consumption of the plant has been connected to a wide range of adverse reactions, such as "skin infections, allergies", "dermatitis, fever", "nasal congestion, dark spots", "scorching, and inflammation" around the eyes.

Figure 3: Effect of Parthenium in human

(Source: Ataei et al. 2021, p.375)

There are several components present in the Parthenium that can impact human health. "Chlorogenic acid", "anisic acid", "p-anisic acid", "caffeic acid", and "benzoic acids" are some of the major components in Parthenium, and they are severely dangerous for humans and cattle. Asthma and allergic bronchitis are bronchial conditions that involve selecting over years of continual exposure, typically with rising fever and respiratory disease. Parthenium consumption is connected to insufficient food intake in animals, which in response has been linked to losing weight and other medical problems (Ataei et al. 2021, p.375). Animal experiments have revealed that parthenium inhibits their reproductive functions. Excessive consumption of the plants can result in a variety of fertility issues, including infertility, abortion, and miscarriages.

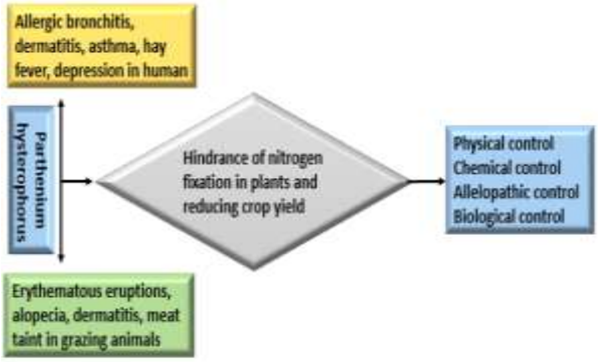

Figure 4: Detrimental effect of P. hysterphorus along with its control management

(Source: Ataei et al. 2021, p.375)

There may be allelopathic effects on agricultural development and growth from introducing Parthenium waste immediately into the soil. Infested plots had much higher nitrogen and organic content than control crops. The development of P. hysterophorus has delayed or superseded both native and non-native species (Saleh, 2021., p. 24). Scientists agree that P. hysterophorus leaves contain allelochemicals, which are subsequently released into the soil by leaching or degradation, where they can both have direct and indirect consequences for plant development by modifying the soil's physical and chemical properties. "High tissue levels of nitrogen" (3%), "phosphorus (2%), potassium" (4%), and other macroand micronutrients made Parthenium weed a good green fertilizer for agricultural production, even when produced in carbohydratesoils (Dara, 2019, p.12). On the other hand, parthenium has an allelopathic influence on the "sprouting and development of other plants".

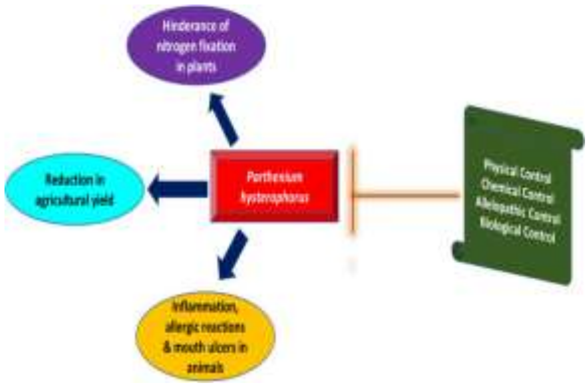

Figure 5: Overall harmful impact of P. hysterophorus

(Source: Raimi, 2021, p.1002)

The invisibility of parthenium in grasslands raises the probability that cattle will feed it if grassland administrators do not eliminate the weed. Reduced feed quality is one method in which parthenium decreases cattle productivity. The nutrition, milk productivity, and carcass quality of grazing animals may also decline as a consequence. Hypoplasia eruptions, baldness, skin discoloration, and hypoglycemia are observed in buffalo and mixed calves that have been treated with P. hysterophorus. Anorexia and erythema can emerge during 12 weeks of P. hysterophorus when fed to matured cows (Parida et al. 2021, p.105966). Cattle can become infected if they ingest Parthenium or come into regular communication with the weed. Potential effects include "death", "skin reactions", "vomiting", "starvation", and "itchiness", "alopecia", "loss of skin melanin", "allergic reactions" to substances, and "allergy".

The beneficial effect of P. hysterophorus as antidiabetic, antioxidant, antitumor and antimicrobial activities

Antidiabetic effects

The aqueous extract of P. hysterophorus has been found to have significant hypoglycemic effects. Alloxan-induced diabetic rats noticed an enormous decrease (p 0.01) in their "fasting blood glucose levels" within 2 hours. Hence, this treatment might be helpful, particularly for insulin-dependent individuals with type II diabetes (Raimi, 2021, p.1002). "Tea made from" "the leaves and roots of P. hysterophorus has been" utilised to cure women's vaginal and urinary disorders. The distilled liquor of P. hysterophorus has been utilised to "treat fever", "neurological conditions", "diarrhoea, urine infections", "malaria, and as an emmenagogue". Several native communities also use it to alleviate the symptoms of "eczema", "rheumatism", "cardiovascular disease", and "pregnancy complications".

Antioxidant effect

Free radicals are believed to be a significant factor in the onset of some diseases because of the carcinogenic effects they have. Antioxidants that are produced are regarded to be contributory factors. The interest of researchers has been aroused by natural antioxidants for this very reason. As evaluated againstthe effect of Stevia, the methanolic extracts of P. hysterophorus showed much higher levels of antioxidant action. As a result, this plant could be a suitable natural antioxidant source (Harrison et al. 2019, p.320). After studying parthenium for its important antioxidant ingredient, a novel, a powerful naturally produced antioxidant may one day be made available for purchase in the market.

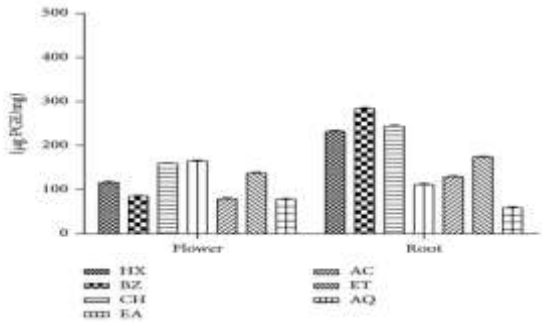

Figure 6: Antioxidant effect of Parthenium hysterophorus

(Source: Płotka-Wasylka & Wojnowski, p.8657)

Antitumor effect

Many investigations have looked into Parthenium and its ingredients for their prospective anticancer activity. In a survey conducted on animals with Ehrlich ascites tumor, Parthenium extract has been developed to decrease their expansion. Flavonoids and other phenolic components in the extract have been important for this effect.

The influence of Parthenium extract on cells of breast cancer has been on the basis of another experiment (Płotka-Wasylka & Wojnowski, p.8657). Researchers showed that the extract reduced the expansion of cancer cells and induced their mortality.

One potential reason for "Parthenium extract's anticancer properties"has been recommended, the ingredient alters the activity of the enzymes in charge of cell growth and programmed cell death. Parthenium includes a compound called parthenolide, the carcinogenic capabilities of which have been continued in its efforts (Tait et al. 2021, p.1950).. Apoptosis induction by parthenolide has been demonstrated in various carcinoma cells, including those generated from leukaemia, prostate, and breast cancers.

Antimicrobial effect

"Antimicrobial secondary metabolites" have been discovered in P. hysterophorus, comprising "alkaloids", "flavonoids", "terpenoids", and "phenolic compounds". Several pathogenic bacteria, including "Escherichia coli", "Staphylococcus aureus", "Salmonella typhi", and "Pseudomonas aeruginosa", have been demonstrated to be inhibited by these compounds. In addition,"Candida albicans", "Aspergillus niger", and "Fusarium solani" have all been shown to be inhibited by P. hysterophorus extracts.

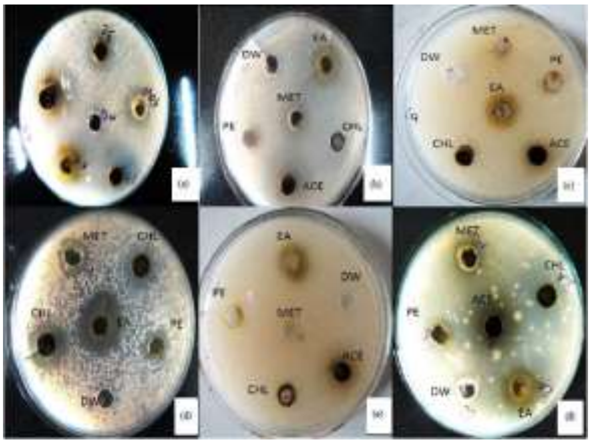

Figure 7: Antimicrobial effect of P. hysterophorus

(Source: DiBartolomeis et al. 2019, p.220029)

P. hysterophorus's antiviral activity against herpes "simplex virus type 1 (HSV-1)" and "human immunodeficiency virus (HIV)" has also been investigated (DiBartolomeis et al. 2019, p.220029). P. hysterophorusextracts are believed to impede the spread of "herpes simplex virus 1" and inhibit the virus from accessing host cells.

Chemical constituents of P. hysterophorus

Sesquiterpene lactones, flavonoids, alkaloids, and essential oils are among the many chemical components found in P. hysterophorus has the following primary chemical components, it contains a variety of sesquiterpene lactones, the most abundant of which is parthenin (Kumar et al. 2019, p.132). P. hysterophorus contains the "flavonoids quercetin", "luteolin", and "kaempferol" in significant amounts. "Antioxidant", "anti-inflammatory", and "cancer-preventative" activities have all been observed in flavonoids.

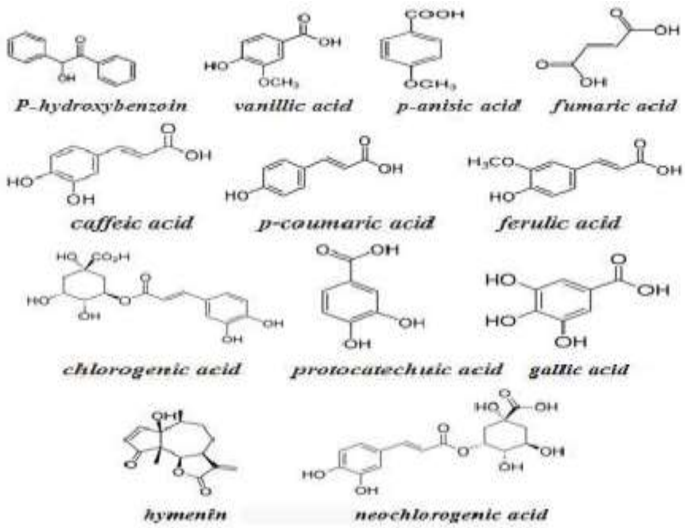

Figure 8: Chemical constituents of P. hysterophorus
(Source: Talukder et al. 2020, p. 6)

P. hysterophorus contains the "alkaloids vasicine" and "vasicinone". There is evidence that certain alkaloids have "anti-inflammatory", "anti-cancer", and "antimicrobial" effects. Moreover, P. hysterophorus includes essential oils, which have been linked to beneficial effects against cancer, inflammation, and microbes. Limonene, pinene, and caryophyllene are the main components of P. hysterophorus essential oil (Talukder et al. 2020, p. 6). Several different biological functions have been attributed to these chemical components of P. hysterophorus. It has medical useshowever, it should be used with caution because it might induce allergic reactions in certain people. As a result of the potential for ecological and economic damage, P. hysterophorus's usage should be limited to carefully monitored settings.

Chemical control of P. hysterophorus

Herbicides are discovered to be extremely successful in controlling parthenium in a variety of studies. In contrast to herbicides, which work through various physiological mechanisms, several photosynthetic substances, such as “amino acid amalgamation” and “glutamine synthase inhibitors”, showed a strong reaction to killing parthenium.

However, “post-emergence herbicides” used during the plant’s initial phases of development are quite efficient against it. “Physical”, “biological”, “cultural”, “mechanical”, and “chemical” weed control methods are all employed in grain production. The chemical method of weed management represents the most timeand expense option (Punja, 2021, p. 3861). The greatest advantage of using this technique is how untouched it is by unpredictable environmental variables like “wind speed”, “temperature”, and “humidity”.

Herbicides such as “atrazine”, “metribuzin”, “S-metolachlor”, “pendimethalin”, “bromoxynil + MCPA”, “atrazine + Smetolachlor”, “triasulfuron + terbutryn”, and “glyphosate” has been evaluated in a non-cropped area. It has been shown that “metribuzin” and “glyphosate” has been proven to be the most efficient herbicides against parthenium. 6 different herbicide treatments can be applied to the crop, but pre-emergent “S-metolachlor + atrazine” proved to be the most efficient in preventing the growth of parthenium and related weeds.

Herbicide	**Taxa**	**Biological Effect**
Glyphosate		
	Water flea *Daphnia magna*	Acute 48h EC_{50} is 218 mg/L (ECOTOX)
	Amphipod *Gammarus pseudolimnaeus*	Acute 48h EC_{50} is 42-62 mg/L (ECOTOX)
	Buzzer midge *Chironomus plumosus*	Acute 48h EC_{50} is 55 mg/L technical glyphosate and 13mg/L Roundup® surfactant (Folmar et al. 1979)
	Mayfly *Ephemerella walkeri*	Avoided Roundup® at 10 mg/L but not 1.0 mg/L (Folmar et al. 1979)
	Channel catfish *Ictalurus punctatus*	Acute 96h LC_{50} is 130mg/L technical glyphosate and 13mg/L Roundup® surfactant (Folmar et al. 1979)
	Fathead minnow *Pimephales promelas*	Acute 96h LC_{50} is 97mg/L technical glyphosate and 1.0 mg/L Roundup® surfactant (Folmar et al. 1979)
	Rainbow trout *Oncorhynchus mykiss*	More sensitive response to Roundup® at elevated temperatures and at pH as it rises from 6.5 to 7.5, with no increased sensitivity at pH beyond 7.5 (Folmar et al. 1979)
	Bluegill sunfish *Lepomis macrochiru*	
	American ribbed fluke snail *Pseudosuccinia columella*	Continuous exposure across generations produced reproductive effects on the third generation including rapid embryonic development, embryonic abnormalities and increased egg laying (Tate et al. 1997)

Table 1: Biological effect of Glyphosate herbicide

(Source: Punja, 2021, p. 3861)

Atrazine		
	Midge *Labrundinia pilosella*	Reduced emergence at 20 ug/L (Dewey 1986)
	Cream and brown microcaddisfly *Oxyethira pallida*	Shift in emergence period at 20 ug/L (Dewey 1986)
	Non-predatory insects	Reduced abundance at 20 ug/L (Dewey 1986)
	Stonewort algae *Chara* sp.	Resistant to atrazine up to 100 ug/L (Dewey 1986)
	Tiger salamander *Ambystoma tigrinum* sp.	Increased larval stage duration, reduced weight and body size (Larson et al. 1998)
	Hydra sp.	48 hr LC_{50} of 3,000 ug/L (lowest acute value) (U.S. EPA 2003)
	Goldfish *Carassius auratus*	96 hr LC_{50} of 60,000 ug/L (highest acute value) (U.S. EPA 2003)
	Water flea *Ceriodaphnia dubia*	Life cycle chronic value of 3,536 ug/L (highest chronic value) (U.S. EPA 2003)
	Brook trout *Salvelinus fontinalis*	Life cycle chronic value of 88.32 ug/L (lowest chronic value) (U.S.EPA 2003)

Table 2: Biological effect of Atrazine herbicide

(Source: Punja, 2021, p. 3861)

Screening the efficacy of various herbicides against parthenium weed in particular season, researchers have tested that “pendimethalin”, “S-metolachlor + atrazin”, “bromoxynil + 2-methyl4-chlorophenoxyacetic acid”, and “atrazine” at half the lesser and half the higher dosages. They found that the optimal herbicide mixture helps to eliminate parthenium weeds and improve grain yield is “S-metolachlor + atrazine (postemergence)” at the recommended level.

The carrying capacity is known as the maximum level of pesticides that can be used to eliminate pests without harming the environment. It has been observed that annual rainfall of near about 600 to 800 mm on the cracking clay soils can decrease the carrying capacity related to the farms.

2. Materials And Methods

The scientific method of studying the cause-and-effect linkages that exist between variables is known as the experimental research design. In this form of study design, the researcher attempts to determine the impacts that one or more independent variables have on a dependent variable by manipulating those variables while simultaneously controlling for the effects of any other variables that may have an effect on the outcome (Hollender et al. 2019, p. 9). As in the present study the effect of P. hysterophorus on crop production has been well-experimented, an **experimental research design** has been followed that started with the collection of plant material including seeds of P. hysterophorus and tomato M-82 seeds has been obtained.

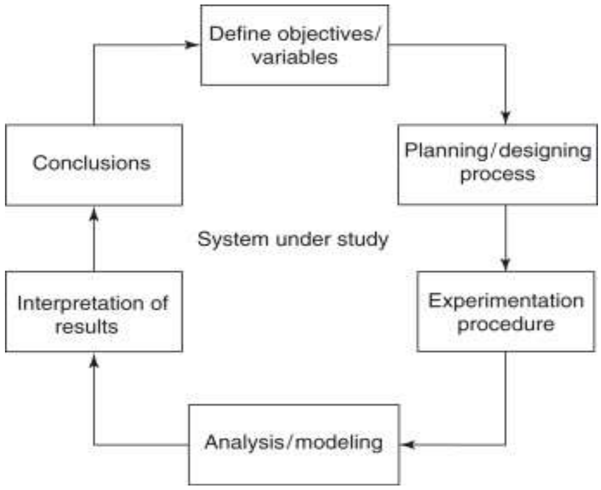

Figure 9: Experimental research design

(Source: Hollender et al. 2019, p. 9)

After that, the "seed germination" and "seedling emergence" has been carried out with "28/22° C Day/night with 12 photoperiods". In the plant growth stage during "one- to two-leaf stage", "uniform seedlings" has been transplanted into a "90 L (60 x 50 x 30 cm) styrofoam watertight container" with "loamy sand soil (Typic Haploxeralfs) pH 7.5", "comprising 6% clay", "3.5% silt", "90% sand" without having any organic matter.

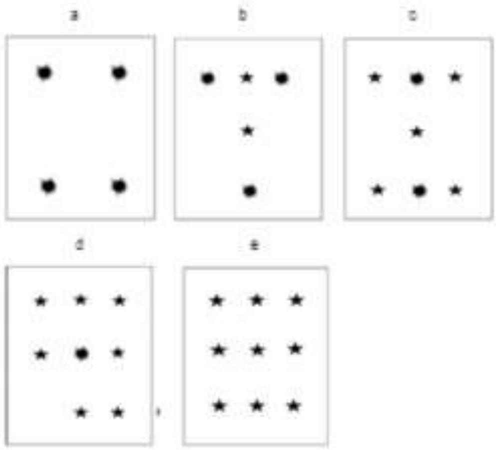

Figure 10: Different ratios of planting designing of tomatoes and P. hysterophorus: "100/0, 75/25, 50/50, 25/75"

(Source: Yaacoby et al, 2023, p. 27)

A grand total of nine P. hysterophorus seedlings have been planted for each container, while only four tomato seedlings have been planted per container corresponding to ground planting with a separation distance of "30 to 40 cm" between seedlings and single row (Yaacoby et al, 2023, p. 26). It has been fertilized with "soluble 20-20-20 (N-P-K) fertilizer" (Islam et al. 2021, p. 9). The total experiment has been conducted "with 4 replicates". In the experimental method the seedling has been planted with different densities by "replacement designing". The design has been like below–

"100% crop - No weed", "75% crop - 25% weed", "50% crop - 50% weed", "25% crop - 75% weed" and "No crop - 100% weed".

3. Results and Discussion

In the study statistical analysis has been performed to understand the change of tomato production with increasing numbers of P. hysterophorus. Using the replacement principle, replacement studies quantify the level of competition between species (Lamichhane et al. 2020, p. 613). Starting with a monoculture of species 1, additional species are slowly introduced into the mix "until a monoculture of species 2" is established. The "replacement-series model" ("substitutive experiment") has been devised to tackle the drawbacks "of the additive design" and is frequently employed to assess the competition of two species and discover more about their mutualistic connections. "The replacement series" is most helpful for clarifying the basis of species interactions, whether they are positive, negative, or neutral.

 Available online at: https://jazindia.com

In a replacement sequence, there are different most possible results of the interaction between a crop species and a weed. (1) Both of the output responses that have been seen are straight lines. "One species is more aggressive" compared to the other. (2) Both response "curves are convex" and the average production of the two species in a made by mixing stand is lower than their corresponding yields in a pure stand. (3) Both response "curves are convex" and the average production of the two different species in a mixed stand is less than that of their corresponding yields in a pure stand (Kaikkonen et al. 2021, p. 71). It is a case of symbiosis if "the total yield of the two species" in a "mixed stand is greater" than the total of their separate yields in a to forward, but it is an instance of mutual antagonism if the response curves for both species are concave.

Planting ratio	Parthenium F.W. (g plant^{-1})	Tomato F.W. (g plant^{-1})	Container total F.W. (g)
T-100	0	340^{A} (±71.98)	1,360
T-75 + P-25	210^{B} (±33.65)	307^{A} (± 37.89)	1,343
T-50 + P-50	262^{AB} (±69.32)	186^{B} (±36.12)	1,683
T-25 + P-75	333^{A} (±118.05)	196^{B} (±72.16)	2,533
P-100	210^{B} (±24.83)	0	1,894
Planting ratio	Parthenium D.W. (g plant^{-1})	Tomato D.W. (g plant^{-1})	Container total D.W. (g)
T-100	0	52^{B} (±5.49)	211
T-75 + P-25	41^{CD} (±7.99)	42^{BCD} (± 4.55)	212
T-50 + P-50	50^{BC} (±8.78)	31^{E} (±4.06)	317
T-25 + P-75	64^{A} (±12.25)	40^{DE} (±4.84)	493
P-100	37^{DE} (±3.21)	0	333

Table3: FW and DW weight of P. hysterophorus and tomato in various planting ratios

(Source: Illustrated by Yaacoby et al, 2023. p. 29)

The data shows that compared to tomatoes that are planted individually, fresh and dry biomass of tomatoes have been reduced when P. hysterophorushas been included. The fresh weight of tomatoes fell whereas that of P. hysterophorus increased. Moreover, when P. hysterophorus plants have been grown in place of tomato plants, the F.W. of the second variety grew by 11–75% while the F.W. of the former dropped by 18–40%.

It has been observed from the study that in the consideration of entire biomass accumulation, the combined biomass in the mixture ratio has been higher in comparison to monoculture. It has also been found that the biomass of P. hysterophorus has been significantly lower when it is planted alone, it can happen due to competition among intra species. In the substitution scenarios it can be expected that the amount of tomato biomass has decreased near about 85%. Different research evidence has supported the increasing number of weed competitiveness mainly amended with potassium, phosphorus and nitrogen (Jepson et al. 2020, p. 61). The elevated concentrations seen in the field reservoir under intensive fertilization have not reached despite the efforts to amend the competitive plants with N:P: K. However, despite this, the results might serve as a benchmark for forecasting future competitiveness in the field. Researchers have expected that P. hysterophorus to be at least as competitive in real-world crop fields in comparison to the lab.

In addition to the competitiveness of weed and crop, a "strong interspecific competition" has been found when it has grown into monoculture (100/1 ratio) (Bashar et al, 2021, p. 1514). The recorded dry and fresh weight of the weed plants in the monoculture has been recorded as much lower in comparison to the ratio of 75/25 planting.

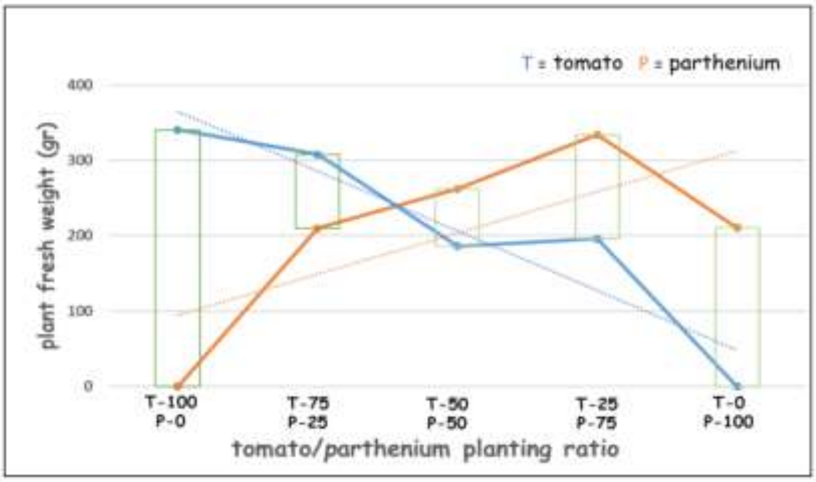

Figure 11: Impact of competition in between Parthenium and tomato at various ratio on "shoot fresh weight"

(Source: Yaacoby et al, 2023, p. 30)

It shows "raw material consumption" and "GDP per capita (PPS)" in the European Union (EU) from 2000 to 2020, with the nonlinear curve smoothed out. Raw materials cost increases to have a nonlinear connection to gross domestic product per capita, as shown by the graph. The correlation is mildly negative, that is 0.212, and it is only barely meaningful with the p-value of 0.05 (Yadav et al. 2021, p. 9). The finding suggests that an increase in income can decrease demand for raw materials, but after a certain income threshold, demand appeared to have increased once more.

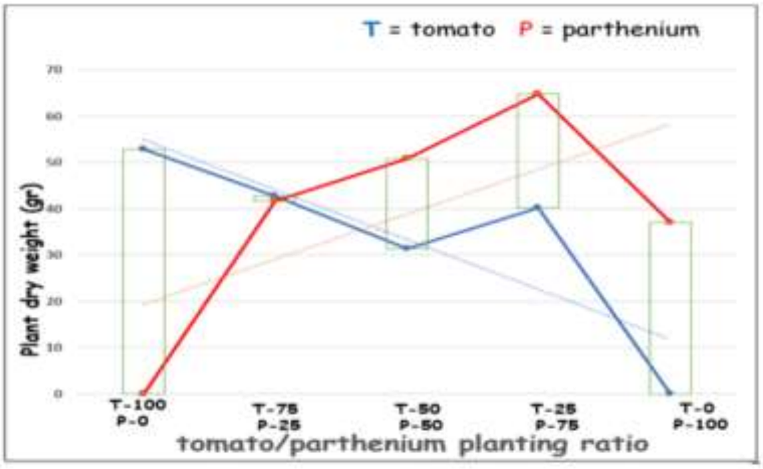

Figure 12: Impact of competition in between Parthenium and tomato at various ratio on "shoot dry weight"

(Source: Yaacoby et al, 2023, p. 27)

Many factors, including "crop type", "soil fertility", "climate", and "management approaches", can affect the carrying capacity of P. hysterophorus in crop production. In general, if there are more than 10 plants per square meter of the weed, it can drastically impair agricultural production. Since, research suggests that with proper weed management, crop yields can be sustained at densities of up to 20 plants per square meter (Despotović et al. 2019, p. 1201). Hence, to keep crop yields high, it is vital to employ integrated weed management strategies such as "cultural control", "mechanical control", "chemical control", and "biological control" that target the various stages of growth of P. hysterophorus. Through reducing the weed population before it reaches a critical mass, these methods boost agricultural yields.

In areas where apex predators are lacking, parthenium could be effectively managed using chemical means (Langenbach et al. 2021, p. 2). "Herbicides" such as "chlorimuron ethyl", "glyphosate, atrazine, ametryn", "bromoxynil, and metsulfuron" have been demonstrated to be quite effective in eradicating this nuisance plant. At 15 days after spraying (DAS), references found that the application of 2, "4-D EE (0.2%) and metribuzin" (0.25 and 0.50%) has been more successful at controlling parthenium, eliminating the entire parthenium population and avoiding any weed growth.

According to many studies, the rosette phase is the most effective time for herbicidal control of parthenium weed in “non cropped areas”, “along railway tracks”, “water channels”, and “roadsides”. Glyphosate and metribuzin are much more efficient than “2, 4-D”, “triasulfuron + terbutryn”, “bromoxynil + MCPA”, and “atrazine + s-metolachlor”, “atrazine”, “s-metolachlor”, at the rosette and bolting phases of the parthenium weeds (Jactel et al. 2019, p. 427). For both developmental phases, “pendimethalin” has been the least effective therapy. In general, rosette parthenium plants reacted differently to herbicides than their bolting counterparts. The table mentioned below mainly shows the relative efficacy of different herbicides against plants in the rosette and bolted stages. Spraying a solution of “common salt (Sodium chloride)” at a level of 15-20% has been demonstrated its efficacy on “open wasteland”, “noncropped areas”, “along railway tracks”, and “roadsides”.

Table 1

Parthenium weed control at rosette and bolted stages with different herbicidal application at 4 weeks after treatment (WAT).

Serial number	Herbicides	Mortality at rosette stage	Mortality at bolted stage
1	Glyphosate	96	91
2	Metribuzin	87	75
3	2,4-D	71-80	43
4	Bromoxynil + MCPA	57-79	50-61.5
5	Atrazine	56.5	36.5
6	S-metolachor	57.5	41
7	Pendimethalin	42.5	30

Figure 13: Control of Parthenium in rosette stage

(Source: Moss, 2019, p. 1207)

Studies have shown that control of P. hysterophorus in the rosette stage is best for its treatment (Okeke et al. 2020, p. 295). According to different studies and its statistical significance, the impact of several herbicidal treatments on the mortality of parthenium plants in non-cropped conditions remained high.

Herbicides increased rates of death from 32.5% to 89.0% at “2 WAT” and “42.5% to 96.0% at 4 WAT”. After 4 weeks of treatment (WAT), glyphosate showed the highest weed death (96%) while “metribuzin graphs” show the second-highest (87%) levels of weed mortality. Glyphosate-sprayed parthenium turned white the day after spraying and died entirely a week afterwards (Moss, 2019, p. 1207). All of the plants have been checked for indications of regrowth, but those treated to glyphosate or metribuzin exhibited none. At the rosette stage, glyphosate produced greater than 93% “control of parthenium weeds” (Pérez-Lucas et al. 2019, p. 25). More than 80% control of parthenium weed has been achieved with post-emergence treatments of “acifluorfen”, “bentazon”, “glyphosate”, “imazaquin”, and “metribuzin” on plants smaller than 7.5 cm. Control has only been achieved around 71% and 80% while using “2, 4-D”, “trisulfuron + terbutryn”, “bromoxynil + MCPA”, or “atrazine + s-metolachlor”.

Crop productivity is decreased as “P. hysterophoruscompetes” for space, water, and nutrients with the crops. Reducing the population of non-target animals, such as beneficial insects and microorganisms plays a vital part in ecosystem functioning, can reduce the carrying capacity of an ecosystem if pesticides are used to manage P. hysterophorus. Soil and water contamination from pesticide use can potentially threaten plant and animal life (Liu et al. 2021, p. 262). Ecosystems containing P. hysterophorus can have their carrying capacities maintained through the employment of many sustainable methods of weed control that is also known as “integrated weed management”. Cultural control through crop rotation and intercropping, physical control by manual weeding and mowing, and biological control are all possible components of an integrated weed strategy for “P. hysterophorus” like the use of natural enemies or plant extracts.

However, cautious use of pesticides may be needed if the“P. hysterophorus” infestation is severe and threatens crop productivity. Use insecticides that target“P. hysterophorus” but are relatively harmless to non-target organisms (Rathi et al. 2021, p. 797). Pesticides can have substantial negative impacts on the natural world; therefore, it is important to apply them safely and in conformity with authorised guidelines to reduce such effects to a minimum and maintain the ecosystem’s carrying capacity.

Using integrated weed management practices that reduce the weed population while reducing environmental impacts is the best way to keep an ecosystem with P. hysterophorus functioning at its max capability. Pesticides should be used with care and only as a last resort, in compliance with all safety precautions and regulations. The effectiveness of "bromoxynil+MCPA" in eliminating "rosette parthenium weed" (57–79%) has been similar with that of bromoxynil alone and in eliminating parthenium weed in grain sorghum (47–82%).

Atrazine and s-metolachlor proved highly comparable in their capacity to eradicate parthenium weed (Lengai et al. 2020, p. 7). These percentages are similar, coming in at 56.5 %. At 4 weeks after treatment (WAT), pendimethalin produced the lowest mortality of parthenium weed at 42.5%. Based on these initial reports, it appears that growers in the area under consideration would be best served by changing to glyphosate due to its low cost, wide availability on the market, and comparatively minor environmental impact.

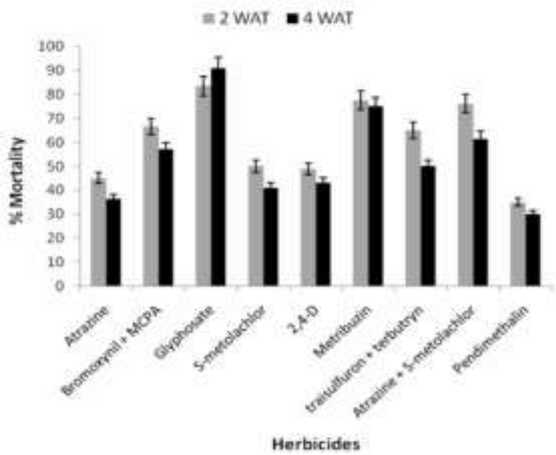

Figure 14: Weed control of Parthenium in rosette stage with herbicidal application in 2WAT and 4WAT

(Source: Yan et al. 2021, p. 24)

Chemical control of "P. hysterophorus" is harmful for the environment because over the use of pesticides causes negative effect to the non-target animals and as well as to the environment. Beneficial insects, birds, fish, and animals are all at risk when using herbicides like glyphosate or 2,4-D (Yan et al. 2021, p. 24). Chemicals have the potential to kill or injure these organisms, which in turn can alter "ecosystems and reduce biodiversity". Lakes, rivers, and groundwater may be contaminated if glyphosate is able to seep into these water sources. Both aquatic life and human health are at risk from this. Polluting soil and water supplies, these herbicides have a lengthy half-life in the environment.

Long-term health impacts may also result from its accumulation in the food chain. In some cases when herbicide is used excessively, weeds can become resistant to it, reducing the herbicide's effectiveness and necessitating more frequent and more potent applications of the chemical (Vurro et al. 2020, p. 2407). Cancer, sterility, and other reproductive and developmental issues have all been related to 2,4-D exposure. Herbicide has the potential to kill off beneficial microorganisms that are essential to keeping soil healthy and fertile.

4. Conclusion

It can be concluded from the study that at various establishment levels, "Partheniumhysterophorus" is a major threat to crop fields. In the competition experiment, "P. hysterophorus"has been found to significantly reduce the fresh and dry shoot weight of crops after only some days of growth, and this has been with the ideal conditions for both species. As herbicides, glyphosate, 2,4-D, atrazine and many more have been identified. Along with that the carrying capacity and negative impact of these herbicides on the environment has been idealised with the concept of environmental sustainability.

Conflict of Interest

In the entire study none of data are listed that can create conflicts among the readers' community. All the academic interest those have been interpreted here are ensured to not harm anyone's personal interest and creating rivalries.

References:

Ataei, P., Gholamrezai, S., Movahedi, R., & Aliabadi, V. (2021). An analysis of farmers' intention to use green pesticides: The application of the extended theory of planned behavior and health belief model. Journal of Rural Studies, 81, 374-384. https://doi.org/10.1016/j.jrurstud.2020.11.003

Baker, B. P., Green, T. A., & Loker, A. J. (2020). Biological control and integrated pest management in organic and conventional systems. Biological Control, 140, 104095. https://www.sciencedirect.com/science/article/am/pii/S1049964419301586

Bashar, H. K., Juraimi, A. S., Ahmad-Hamdani, M. S., Uddin, M. K., Asib, N., Anwar, M. P., & Rahaman, F. (2021). A Mystic Weed, Parthenium hysterophorus: Threats, Potentials and Management. Agronomy, 11(8), 1514. https://www.mdpi.com/1208666

Dara, S. K. (2019). The new integrated pest management paradigm for the modern age. Journal of Integrated Pest Management, 10(1), 12. https://doi.org/10.1093/jipm/pmz010

Despotović, J., Rodić, V., & Caracciolo, F. (2019). Factors affecting farmers' adoption of integrated pest management in Serbia: An application of the theory of planned behavior. Journal of Cleaner Production, 228, 1196-1205. https://doi.org/10.1016/j.jclepro.2019.04.149

DiBartolomeis, M., Kegley, S., Mineau, P., Radford, R., & Klein, K. (2019). An assessment of acute insecticide toxicity loading (AITL) of chemical pesticides used on agricultural land in the United States. PloS one, 14(8), e0220029. https://doi.org/10.1371/journal.pone.0220029

Harrison, R. D., Thierfelder, C., Baudron, F., Chinwada, P., Midega, C., Schaffner, U., & Van Den Berg, J. (2019). Agro-ecological options for fall armyworm (Spodoptera frugiperda JE Smith) management: Providing low-cost, smallholder friendly solutions to an invasive pest. Journal of Environmental Management, 243, 318-330. https://doi.org/10.1016/j.jenvman.2019.05.011

Hollender, J., Van Bavel, B., Dulio, V., Farmen, E., Furtmann, K., Koschorreck, J., ...& Tornero, V. (2019). High resolution mass spectrometry-based non-target screening can support regulatory environmental monitoring and chemicals management. Environmental Sciences Europe, 31(1), 1-11. https://link.springer.com/article/10.1186/s12302-019-0225-x

Hubert, T. D., Miller, J., & Burkett, D. (2021). A brief introduction to integrated pest management for aquatic systems. North American Journal of Fisheries Management, 41(2), 264-275. https://doi.org/10.1002/nafm.10331

Islam, M., Hoque, M. Z., Alam, M. Z., Afrad, M., Islam, S., Haque, M., & Hasan, S. (2021). Pest risk analysis and management practices for increasing profitability of lemon production. Journal of Agriculture and Ecology Research International, 22(1), 26-35. https://doi.org/10.9734/jaeri/2021/v22i130181

Jactel, H., Verheggen, F., Thiéry, D., Escobar-Gutiérrez, A. J., Gachet, E., Desneux, N., & Neonicotinoids Working Group. (2019). Alternatives to neonicotinoids. Environment international, 129, 423-429. https://doi.org/10.1016/j.envint.2019.04.045

Jepson, P. C., Murray, K., Bach, O., Bonilla, M. A., & Neumeister, L. (2020). Selection of pesticides to reduce human and environmental health risks: a global guideline and minimum pesticides list. The Lancet Planetary Health, 4(2), e56-e63. https://doi.org/10.1016/S2542-5196(19)30266-9

Kaikkonen, L., Parviainen, T., Rahikainen, M., Uusitalo, L., & Lehikoinen, A. (2021). Bayesian networks in environmental risk assessment: A review. Integrated environmental assessment and management, 17(1), 62-78. https://doi.org/10.1002/ieam.4332

Kumar, S., Nehra, M., Dilbaghi, N., Marrazza, G., Hassan, A. A., & Kim, K. H. (2019). Nano-based smart pesticide formulations: Emerging opportunities for agriculture. Journal of Controlled Release, 294, 131-153. https://doi.org/10.1016/j.jconrel.2018.12.012

Lamichhane, J. R., You, M. P., Laudinot, V., Barbetti, M. J., & Aubertot, J. N. (2020). Revisiting sustainability of fungicide seed treatments for field crops. Plant Disease, 104(3), 610-623. https://doi.org/10.1094/PDIS-06-19-1157-FE

Langenbach, T., Caldas, L. Q., De Campos, T., Correia, F., Lorenz, N., Marinho, D., ...& Vieira, E. (2021). Perspectives on Sustainable Pesticide Control in Brazil. World, 2(2). https://doi.org/10.3390/world2020018

Lengai, G. M., Muthomi, J. W., &Mbega, E. R. (2020). Phytochemical activity and role of botanical pesticides in pest management for sustainable agricultural crop production. Scientific African, 7, e00239. https://doi.org/10.1016/j.sciaf.2019.e00239

Liu, J., Zhou, J. H., Guo, Q. N., Ma, L. Y., & Yang, H. (2021). Physiochemical assessment of environmental behaviors of herbicide atrazine in soils associated with its degradation and bioavailability to weeds. Chemosphere, 262, 127830. https://doi.org/10.1016/j.chemosphere.2020.127830

Lykogianni, M., Bempelou, E., Karamaouna, F., & Aliferis, K. A. (2021). Do pesticides promote or hinder sustainability in agriculture? The challenge of sustainable use of pesticides in modern agriculture. Science of the Total Environment, 795, 148625. https://doi.org/10.1016/j.scitotenv.2021.148625

Mishra, J., Dutta, V., & Arora, N. K. (2020). Biopesticides in India: technology and sustainability linkages. 3 Biotech, 10(5), 210. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7181464/

Moss, S. (2019). Integrated weed management (IWM): why are farmers reluctant to adopt non-chemical alternatives to herbicides?. Pest management science, 75(5), 1205-1211. https://doi.org/10.1002/ps.5267

Okeke, E. S., Ezeorba, T. P. C., Mao, G., Chen, Y., Feng, W., & Wu, X. (2022). Nano-enabled agrochemicals/materials: Potential human health impact, risk assessment, management strategies and future prospects. Environmental Pollution, 295, 118722. https://doi.org/10.1016/j.envpol.2021.118722

Parida, V. K., Saidulu, D., Majumder, A., Srivastava, A., Gupta, B., & Gupta, A. K. (2021). Emerging contaminants in wastewater: A critical review on occurrence, existing legislations, risk assessment, and

sustainable treatment alternatives. Journal of Environmental Chemical Engineering, 9(5), 105966. https://doi.org/10.1016/j.jece.2021.105966
Pérez-Lucas, G., Vela, N., El Aatik, A., & Navarro, S. (2019). Environmental risk of groundwater pollution by pesticide leaching through the soil profile. Pesticides-use and misuse and their impact in the environment, 1-28. https://doi.org/10.5772/intechopen.82418
Płotka-Wasylka, J., & Wojnowski, W. (2021). Complementary green analytical procedure index (ComplexGAPI) and software. Green Chemistry, 23(21), 8657-8665. DOI:10.1039/D1GC02318G
Punja, Z. K. (2021). Emerging diseases of Cannabis sativa and sustainable management. Pest management science, 77(9), 3857-3870. https://doi.org/10.1002/ps.6307
Raimi, M. O. (2021). Self-reported symptoms on farmers health and commonly used pesticides related to exposure in Kura, Kano State, Nigeria. Morufu Olalekan Raimi (2021).“Self-reported Symptoms on Farmers Health and Commonly Used Pesticides Related to Exposure in Kura, Kano State, Nigeria”. Annals of Community Medicine & Public Health, 1(1), 1002. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3771437
Rathi, B. S., Kumar, P. S., &Vo, D. V. N. (2021). Critical review on hazardous pollutants in water environment: Occurrence, monitoring, fate, removal technologies and risk assessment. Science of The Total Environment, 797, 149134. https://doi.org/10.1016/j.scitotenv.2021.149134
Saleh, T. A. (2021). Protocols for synthesis of nanomaterials, polymers, and green materials as adsorbents for water treatment technologies. Environmental Technology & Innovation, 24, 101821. https://doi.org/10.1016/j.eti.2021.101821
Singh, A., Dhiman, N., Kar, A. K., Singh, D., Purohit, M. P., Ghosh, D., & Patnaik, S. (2020). Advances in controlled release pesticide formulations: Prospects to safer integrated pest management and sustainable agriculture. Journal of hazardous materials, 385, 121525. https://doi.org/10.1016/j.jhazmat.2019.121525
Tait, G., Mermer, S., Stockton, D., Lee, J., Avosani, S., Abrieux, A., ...& Walton, V. M. (2021). Drosophila suzukii (Diptera: Drosophilidae): a decade of research towards a sustainable integrated pest management program. Journal of Economic Entomology, 114(5), 1950-1974. https://doi.org/10.1093/jee/toab158
Talukder, B., Blay-Palmer, A., & Hipel, K. W. (2020). Towards complexity of agricultural sustainability assessment: Main issues and concerns. Environmental and Sustainability Indicators, 6, 100038. https://doi.org/10.1016/j.indic.2020.100038
Upadhayay, J., Rana, M., Juyal, V., Bisht, S. S., & Joshi, R. (2020). Impact of pesticide exposure and associated health effects. Pesticides in crop production: physiological and biochemical action, 69-88. https://doi.org/10.1002/9781119432241.ch5
Vurro, M., Miguel-Rojas, C., & Pérez-de-Luque, A. (2019). Safe nanotechnologies for increasing the effectiveness of environmentally friendly natural agrochemicals. Pest management science, 75(9), 2403-2412. https://doi.org/10.1002/ps.5348
Yaacoby, T., Yaacobi, G., & Rubin, B. (2023). The competitiveness of the invasive weed Parthenium hysterophorus with field tomato (Lycopersicum esculentum) in Israel. Ecocycles, 9(1), 25-31. https://doi.org/10.19040/ecocycles.v9i1.253
Yadav, M. K., Saidulu, D., Gupta, A. K., Ghosal, P. S., & Mukherjee, A. (2021). Status and management of arsenic pollution in groundwater: A comprehensive appraisal of recent global scenario, human health impacts, sustainable field-scale treatment technologies. Journal of Environmental Chemical Engineering, 9(3), 105203. https://doi.org/10.1016/j.jece.2021.105203
Yan, S., Ren, B. Y., & Shen, J. (2021). Nanoparticle-mediated double-stranded RNA delivery system: A promising approach for sustainable pest management. Insect Science, 28(1), 21-34. https://doi.org/10.1111/1744-7917.12822