ALLELOPATHIC EFFECT AND CONTROL OF CHINESE WEDELIA (*Sphagneticola calendulacea*)

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CERTIFICATE

*This is to certify that the thesis entitled, "***ALLELOPATHIC EFFECT AND CONTROL OF CHINESE WEDELIA (*Sphagneticola calendulacea*)***" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in AGRONOMY****, embodies the result of a piece of bona-fide research work carried out by* ***MD. MERAJUL ISLAM,*** *Registration no.* ***15-06473*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I certify that such help or source of information, as has been availed of during this investigation, has duly been acknowledged

Date:

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DEDICATED TO

MY

DECEASED FATHER

&

ALL THE FARMERS OF BANGLADESH

LIST OF ACRONYMS

Abbreviations	Full word
AEZ	Agro-Ecological Zone
Agril.	Agricultural
Agron.	Agronomy
ANOVA	Analysis of variance
@	at the rate of
BARI	Bangladesh Agriculture Research Institute
cm	Centimeter
CRD	Complete Randomized Block Design
CV %	Percent Coefficient of Variation
df	Degree of Freedom
°C	Degree Celsius
e.g.	exempli gratia (L), for example
et al.,	And others
et c.	Etcetera
Fig.	Figure
g	Gram (s)
$g\ m^{-2}$	Gram per square meter
i.e.	id est (L), that is
Inst.	Institute
J.	Journal
Kg	Kilogram (s)
LSD	Least Significant Difference
M.S.	Master of Science
m^2	Meter squares
ml	Mili Litre
No.	Number
ns	Non-significant
%	Percentage
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
var.	Variety
viz.	namely

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The author

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ALLELOPATHIC EFFECT AND CONTROL OF CHINESE WEDELIA (*Sphagneticola calendulacea*)

ABSTRACT

Determination of allelopathic effect and control of chinese wedelia (*Sphagneticola calendulacea*) was conducted during November 2022 to February 2023 at Sher-E-Bangla Agricultural University, Bangladesh. Experimental results used evaluated in germination percentage and germination inhibition of different crops and to identify how other crops were affected by this weed. *Sphagneticola calendulacea* was identified using the visual method, and quadrates were used to determine the total biomass and relative biomass of the weeds. The infestation density of *Sphagneticola calendulacea* were found along roadsides, in fallow land, grasslands, and in some crop fields. The highest abundance of *Sphagneticola calendulacea* occurred at fallow land. The allelopathic activity *of Sphagneticola calendulacea* was examined against the seed growth of seventeen crop species including major cereals, pulses, oilseeds, weed seed, and vegetables. 5% aqueous leaf extract and 5% aquas leaf extract with methanol was used to investigate the allelopathic activity of *Sphagneticola calendulacea* to seeds and post-germinated seeds (both radicle and plumule are emerged) of test species. The following three parameters were used in allelopathic screening methodologies (a) germination percentage (%), (b) radicle length (cm), and (c) plumule length (cm). Results of Petri dishes treated with methanolic extract or leaf extract shown a complete failure of germination (0%) due to the treatment in rice, jute, cowpea, black eyed pea, pea and chickpea. Among the cereals, rice had the greatest reduction in radicle and plumule length (100%) and maize had the lowest (61% and 53%, respectively) compared to the respective control with methanol extract. Whereas, the leaf extract increase growth of radicle and plumule in both rice and wheat and highly decrease in maize and slightly in jute. For controlling this weed Filder (2,4,D-Amine) highly reduce (48%) the total biomass of the *Sphagneticola calendulacea* than Sunup 480 SL (glyphoset) and Weednil 5EC (Quizaloph-P-Ethyle) 7% and 8%, respectively. Therefore, an integrated management approach is urgently needed to control the spread of this invasive weed.

CHAPTER I
INTRODUCTION

Sphagneticola calendulacea is a perennial herb native to India, China, and Japan, that is widely distributed in tropical and subtropical areas around the world due to its high tolerance to adverse environmental conditions. It belongs to the Asteraceae family of about 50 to 100 cm height. Leaves are fleshy, usually 5-8 cm long and 3-5 cm wide, irregularly toothed or serrate, usually with a pair of lateral lobes and obviate in shape. Flowers are yellow, tubular in terminal or axillary head and 3-5 cm in diameter.

It is now widely recognized that *Sphagneticola calendulacea* commonly named as Buno daisy or Chinese daisy or Singapore daisy in Bangladesh migrated from China, has become a problematic broadleaf weed in many ecosystems across the world. *Sphagneticola calendulacea*, a member of the Asteraceae family, is a C3 annual broadleaf species with a life cycle of 250–360 days. It is commonly found in gardens, along roadsides, fence rows and in open waste places, of particular interest to this study is that it has been reported to be now a common weed in no less than 31 different crops in more than 140 countries. Some of the crops in which *Sphagneticola calendulacea* has been found as a principal weed are corn, sugarcane, sorghum, cotton, rice, vegetables, and pastures, all of which are critically important to many national economies. Weed infestation depends on the availability of moisture content, soil structure and texture, location of the field, weather and climatic condition of the field, depth of plough pan and organic matter content of soil (Hossen *et al.,* 2015).

It is also used for a variety of purposes around the world, including food and traditional medicine, plant biopesticide, phytoremediation of heavy metal-polluted soils. Traditionally the fruits, leaves and stem are used in childbirth and in the treatment of bites and stings, fever and infection. The leaves are used in the treatment of kidney dysfunction, cold, wounds and amenorrhea (Mathew, 1983).

Sphagneticola calendulacea is a perennial weed in warm areas of the world and is also a serious weed in many crop fields and farms. It is fast growing and very invasive. Invasive plant species may result in a number of ecological and agricultural problems.

Allelopathy is a process by which plants release toxic chemical compounds in their surroundings. *Sphagneticola calendulacea* contains allelopathic substances which affect seed germination, plant growth and chlorophyll synthesis by its leaves. Its allelopathic effects are also useful in improving its capacity in interspecific competition and its invasiveness.

Reports have indicated that *Sphagneticola calendulacea* can cause a 35–85% reduction in the yields of cabbage, tomato, jute, spinach, cucumber, green bean, carrot, okra, wheat, maize, bottle gourd, pumpkin, bell pepper, onion, garlic and many other crops for its allelopathic effect. The relationship between plant allelopathy and competition is difficult to separate and/or isolate due to the complexity of the natural environment. According to a study by Bendixen and Nandihalli (1987), *Sphagneticola calendulacea* is disseminated in over 92 tropical and subtropical countries around the world and causes harvest losses in more than 50 crops.

An methanolic (5 %) extract inhibits the growth of Ehrlich's ascites carcinoma. The extracts of this plant have been tested in experimental animal models for their hepatoprotective effect (Apers *et al.*, 2002).

In the ever-evolving field of agriculture, scientists and researchers are constantly seeking innovative solutions to enhance crop productivity and sustainability. This unique botanical compound, extracted from the renowned medicinal herb *Sphagneticola calendulacea*, has unveiled its remarkable potential as an inhibitor for germination in various crop species.

Preliminary investigations have revealed that the methanolic extract of *Sphagneticola calendulacea* holds remarkable properties that stimulate and accelerate the germination process in a wide array of crops. Its bioactive compounds, carefully extracted and refined, demonstrate a unique synergy that imparts various growth inhibitory effect to germinating seeds. These compounds have been found to diminish seed vigor, increase the speed and uniformity of germination, and even restrict early seedling development.

Unlike conventional germination-enhancing techniques, this botanical extract operates through a delicate balance of bioactive substances that interact with the seed physiology at a fundamental level. It activates vital metabolic processes within the seed, including hormone regulation and enzyme activities, which optimize the conditions for germination and subsequent seedling growth. Furthermore, the methanolic extract of *Sphagneticola calendulacea* exhibits an impressive adaptability to different crop species, displaying a broad spectrum of effectiveness across diverse agricultural contexts. Whether it is cereals, vegetables, legumes, or even trees, this botanical catalyst has demonstrated its potential to unlock the germination potential of a wide range of crops, igniting new possibilities for agricultural productivity.

In conclusion, As, research and experimentation in this field continue, scientists and agricultural experts are eager to explore the countless possibilities offered by the methanolic extract of *Sphagneticola calendulacea*. The potential to revolutionize germination techniques and booster crop yields has inspired a new wave of excitement and anticipation among researchers, farmers, and stakeholders across the agricultural landscape.

In our country, the conventional methods of weed control practices include primarily tillage of the land, hand weeding done by hoe and hand pulling. Routinely, two or three mechanical or hand weeding is done for growing crop depending upon the nature of weeds, their intensity of infestation and the crop grown. Weed control in transplant aman rice by mechanical and cultural methods is expensive (Mitra *et al.,* 2005). On the contrary, chemical control of weed is easier and cheaper than mechanical control of weed. Furthermore, chemical methods lead to environmental pollution and negative impact on public health (Phuhong *et al.,* 2005). For mass production, herbicide-based weed management has become the smartest and most viable option of weed control and low cost of labour (Anower *et al.,* 2012). Consequently, the vegetation of crops and weeds should be seen and regarded as a competitive and cooperative system that has to be managed properly.

Based on the matters, the present experiment was undertaken with the following objectives:

- To determine the allelopathic effect of *Sphagneticola calendulacea* on the germination and inhibition of various crops and weeds seed.
- To find out the interaction of *Sphagneticola calendulacea with* different crop on growth and development of Radicle and Plumule.
- To evaluate the weed control efficiency of different weedicide in *Sphagneticola calendulacea* weed.

CHAPTER II

REVIEW OF LITERATURE

In this section, an endeavor was done to collect and study relevant information available regarding the allelopathic effect and chemical control of *Sphagneticola calendulacea* plant materials to gather knowledge useful to proceed the current work. Because the available literature on this crop is limited, literature on other related crops was gathered and reviewed under the following headings:

2.1 Allelopathic effect on Crop Ecology

Allelopathy refers to the biochemical inhibition of one species by another. The inhibitory chemical is released into the environment, affecting the neighboring plants' development and growth. These biochemicals are known as allelochemicals. For example, *Juglans nigrum* releases an allelochemical 'Juglone', a respiratory inhibitor. When exposed to these allelochemicals, plants (mainly Solanaceae family) exhibit wilting, chlorosis, and death symptoms.

Alam and Islam, (2002) stated that, Plants produce chemicals, which interfere with other plants and affect seed germination and seedling growth. Currently, a number of alien invasive weeds has been confirmed to show allelopathy, such as Solidago Canadensis, and Mikania, among others (Zeng and Luo, 1993; Wang and Zhu, 1996; Hu and Kong, 1997; Shao *et al.,* 2003; Su and Zhu, 2003; Mei *et al.,* 2005; Wan *et al.,* 2011; Lu *et al.,* 2011).

Pharmacological investigations have revealed that *Sphagneticola calendulacea* had effects on di terpenoids, sesquiterpenes, triterpenoids, flavonoids, organic acids, and steroids and has antioxidant, anti-inflammatory and antimicrobial effect (Manjamalai *et al.,* 2012). These chemicals products mainly affect plants at seed emergence and seedling levels (Alam and Islam, 2002).

Einhelling and Leather, (1988) studied that there are about 400,000 secondary metabolites in plants with allelopathic activities of which only a few have been examined. The rest of the compounds, might contain very promising growth inhibitors are still unknown. Since about 12.5% of the total plants species of the world are considered as medicinal plants (Wakdikar, 2004).

Ramanujam *et al.,* (2008) investigated by exposing green grain seeds and seedlings to 0. 1.0,2.5 and 5% concentrations of the aqueous leaf extract adversely affected germination and seedling growth (length, and biomass of shoot, root and plant) lateral root development and nodulation. Besides nodule number and size, the activity of nitrate reductase was inhibited too. Regrettably, traditional breeding methods have not generally been employed to produce highly allelopathic crops with good yield potential. Recent study of the use of genetic materials to enhance allelopathic traits showed that this is not a simple task attributable to the multigenic nature of allelochemicals biosynthesis. Even so, the benefits in monetary and time-savings by reductions in hand labor or weedicide application could be extensive if incorporation of improved allelopathic or weed suppressive ability was beneficial in major agronomic crops (Duke *et al.*, 2002)

Cheema *et al.,* (2002) reported that extract application decreased the weed population, reduced fresh weight of weeds by 48% and dry weight of weed by 50%. Akter *et al.*, (2018) revealed that *C. longa* extracts with curcuminoids are able to inhibit the germination and growth of *Bidens Pilosa*. Leaf extracts of *E. globulus* had phytotoxic effects on germination and seedling growth of *S. nigrum* seeds. The phytotoxicity of volatile oils and extracts of different Eucalyptus species has been reported against many weedy species stated by (Saberi *et al.*, 2013)

Djanaguiraman *et al.*, (2005) observed that the leaf leachate of *E. globulous* inhibited germination and growth of rice, sorghum and blackgram. Moreover, the extract of *E. globulous* inhibited germination and seedling growth of green gram and cowpea.

Arshad and Frankenberger (1998) founded that, phytochemicals have shown far- reaching effects on the growth and development of plants even at low concentration. A number of laboratory-based experiments have focused on the effects of leaf sap, volatile compounds, foliage decomposition and root exudation on seed germination and the early growth stages of various receptor species (Molina *et al.*, 1991).

Asgharipour and Armin (2010) observed that phytochemicals might affect both crop and weeds when found together. The crop was distress directly or indirectly by the phytochemicals and lead to either stimulation or inhibition of growth.

Asgharipour and Armin (2010) also reported that the study the phytotoxic of plant organs extract at seed germination and seedling growth stages was beneficial for it is difficult to separate the phytochemicals effects from that of competition among crop and phytotoxic plants. Germination percentage is considered to be an excellent indicator for the detection of allelopathic potential (Bewley *et al.,* 2013).

Devi and Datta (2012) studied the allelopathic effect of the aqueous leaf extract of *P. hysterophorus* on the seed germination, radicle and plumule growth of the seedlings of *Zea mays* by applying five different treatments (2, 4, 6, 8 and 10%) of two plant leaf extracts. Results exhibited that seed germination on account of allelopathic inhibition was found in all levels of leaf extract.

Jabran *et al.,* (2008) conducted a research that, Allelochemicals extracted from various plant species could act as natural weed inhibitors. In a laboratory experiment, four aflelopathic plant extracts (sorghum (*Sorghum bicolor*). mulbern' (*Morus alha*), barnyard grass (*Echionoach loacrusgalli*) and winter cherry (*Withania somnilèra*) were tested for the inhibition of most problematic weed of wheat, canary grass (*Fluluris minor*). It is also used for the assessment of the effects of chemical compounds in the laboratory or the field (Tanveer *et al.*, 2014).

The process of seed germination is complex and involves sequential changes in biochemistry, physiology, and morphology of the seedlings. Disruption of these changes results in hampering proper germination and growth. The presence or absence of some chemical compounds mediates this inhibition (Brewly *et al.,* 2013).

Chatiyanon et al. (2012) reported that the water and methanol extract of the leaves of *H. suaveolens* has phytotoxic effects on the germination and seedling growth of *Pennisetum setosum.*

Norsworthy (2003) reported that, wild radish (*Raphanus raphanistrum*) aqueous extract or incorporated residues (or both) suppress seed germination, radicle growth, seedling emergence, and seedling growth of certain crops and weeds and these responses were attributed to an allelochemical effect. Even though the biochemical processes inhibiting the germination were not clearly defined, allelochemicals in the leaf extract might have a role in increasing respiration and hydrolytic enzyme activity leading to low cell division and embryo enlargement (Aliotta *et al.,* 1994).

Deba *et al.,* 2008) revealed that, A total of 198 compounds have been reported to be present in whole plants of *Sphagneticola calendulacea* with the essential oils β-caryophyllene and τcadinene described as major compounds. Fifteen phenolic compounds have also been reported, with caffeic and ferulic acids described as the major phenolics (Deba *et al.,* 2007).

Allelopathy is an important means of adaptation, survival, and competition, and exists widely in nature; it has become a domestic and international concern, and various studies have been conducted to address these concerns (Jiang *et al.,* 2010)

The difference in response to dormancy breaking pretreatments by the seed depends on environmental conditions, the degree of maturation of the seeds and the duration of storage. (Gunn 1990).

Alcohol stimulates germination in hard coat seeds, particularly those of the Fabaceae, by softening the waxy seed coat, thereby allowing the inflow of water, gaseous exchange and unrestricted expansion of embryonic parts. (Mayer and Poljakoff-Mayber 1989).

Biomass and height of *Solanum melongena* seedlings as well as their root activity were significantly decreased by diisobutyl phthalate addition (Zhou *et al.,* 2010)

Marunda (1990) stated that, Poor germination percentage and energies recorded for the ethanol and 2 min methanol pretreatment may be due to reduced severity of the treatment, which did not render the seed coat soft and permeable to water. Allelopathy is essential in the plant incursion process. The absence of co-evolved tolerance to new chemicals produced by the aggressors by the existing native vegetation allows these invaders to dominate natural ecosystem. (Hierro *et al.,* 2003).

Moyer and Huang (1993) conducted an experiment to observe the effect of crop residue on germination and growth of weeds. In this experiment they used the aqueous extract of six different crop residue which were Canola (*Brassica napus* L.), Rye (*Secale cereale* L.), Barley (*Hordeum vulgare* L.), Oats (*Avena saliva* L.), Indian Head lentil (*Lens culinaris*) and Wheat (*Triticum aestivum* L.). They noticed that crop extract also reduce germination and growth of other crops. Wheat germination was reduced by lentil, oat, and canola extracts at 4%. Wheat root growth was suppressed by all plant extracts except wheat at 1%. None of the extracts inhibited shoot growth at 1%. At 2% extracts of lentil, oat, and canola inhibited wheat shoot growth, and at 4% all plant extracts inhibited shoot growth.

Khalid *et al.,* (2002) stated that allelopathic interactions may be significant in ecosystems by influencing weed control and crop productivity.

Nie *et al.,* (2004) revealed that, Rice (*Oriza sativa*) would have poor growth and low yield after using of *W. trilobata* as green manure. The similar type of germination promotary behavior was also observed in extract of *Cassia angustifolia* (Hussain *et al.,* 2007).

Tawaha and Turk (2003) revealed that soil incorporation of fresh black mustard roots and both roots and shoots reduced wild barley germination, plant height and weight when compared with a no-residue control. In hioassays, black mustard extracts reduced wild barley hypocotyl length, hypocotyl weight, radicle weight, seed germination, and radicle length by as much as 44, 55, 57, 63 and 75 %, respectively, when compared with a water control.

Kaur *et al.,* (2012) revealed that the leaf extracts of *E. globulus* had varying degrees of phytotoxicity against *S. nigrum*. Methanolic and ethyl acetate extracts had maximum inhibitory effects while aqueous extract had least inhibition. Solubility of phytochemicals is one of the major factors determining their phytotoxicity.

Patel *et al.,* (2002) studied the effects of leaf extracts of Eucalyptus and other species on wheat and mungbean. He reported that, the plant extract impeded the rooting rate of wheat by 80-100%. Harmful effects of Eucalyptus did not debased under field conditions. He observed reduction in germination percentage with Eucalyptus leaf extract.

2.2 Allelopathic effect on Seed Germination

Al-Shatti *et al.,* (2015) provided a statement that, The strength of the aqueous extract had a significant role in declining water uptake essential for seed germination. The aqueous extracts of sunflower reduced germination and mean daily germination. (Ghorbani *et al.,* 2008)

Azizi and Fujji (2006) found that Eucalyptus sp. essential oils had a strong inhibitory effect on the germination of *A. retroflexus*.

Jeffersona and Pennacchio (2003) carried out an investigation and revealed that phytochemicals may reduce weed competition with crops by delaying weed germination. These chemicals have harmful effects on crops in the eco-system resulting in the reduction and delayed germination, seedling mortality and reduction in growth and yield (Herro and Callaway, 2003).

Mohamadi and Rajaie (2009) showed that the effects of phytochemicals on seeds germination appear to be mediated through a disruption of normal cellular metabolism rather than through damage or organelles.

Aqueous extracts of leaves have notably inhibited seed germination of sorghum with application of Parthenium hysterophorus ,Ipomoea cornea (Murthy *et al.*, 1995), *Commelina bengahalensis* and *Cyperus rotundus* (Channappagoudar *et al.,* 2003) and *Eucalyptus camaldulensis* (Mohamadi and Rajaie, 2009)

Mubarak *et al.,* (2009) studied an agreement with other studies which showed that sorghum seeds germination was significantly reduced when treated with *Eucaliptus cmaldulensis*.

Singh *et al.,* (1992) showed that, The extract concentrations of allelochemcial will reduce sorghum seeds germination and ultimately results in reduction in yield. These results are in agreement with reduction in germination percentage with extract/ leachates application to wheat seed.

Mubarak *et al.,* (2009) revealed that, *Moringa oleifera*, *Khaya senegalensis* and *Albizia lebek* leaf extracts found to have no significant effects on seed germination of sorghum. The differences in the germination percentage between the cultivars could be attributed to differences in the selective permeability of the seeds coat of sorghum to inhibitory substances (Zakaria and Razak, 1990).

Davasagayam and Ebenezar (1996) conducted a research experiment on allelopathic effect of eucalyptus on aerobic crop and found that seed germination was decreased in all crops by eucalyptus leaf extract. Groundnuts and cowpea were the most tolerant (4 and 6%) decrease in germination, respectively, compared with the control whereas inhibition was high in Sorghum (16.3%) Soyabean (10.9%), Maize (8.9%) and Blackgram (7.1%).

2.3 Allelopathic effect on seedling growth

Asgharipour and Armin (2010) showed that, Allelo chemicals emancipated as residues, exudates and leaches by many plants from leaves, stem, roots, fruit and seeds reported to interfere with growth of other plants.

Chung *et al.,* (2001) assessed the allele pathic potential of 44 rice cultivars (*Oryza sativa* L.) on barnyard grass. All 44 cultivars exhibited marked differences in the inhibition of barnyard grass growth and development. Green manure of aromatic plants could be used for the suppression of barnyard grass and some broadleaf weeds in maize which consequently minimize herbicide usage (Dhima *et al.,* 2009).

Phiri, (2010) carried out an experiment on effect of *M. oleifera* leaf extracts on sorghum indicated 15.3% reduction in survival seedlings.

Rice, (1984) stated that allelochemicals cause germination and growth inhibition, and influence a wide variety of metabolic processes. These substances can be isolated from plant tissues. Allelochemicals can be found in numerous parts of a plant such as roots, rhizomes, leaves, stems, pollen, seed, and flowers, and are usually products of secondary plant metabolism. Aqueous Eucalyptus extract was effective in general to cause growth inhibition. But all plants of same species were not equally susceptible to aqueous extracts of Eucalyptus (Dawar *et al.*, 2007).

Colquhoun (2006) evaluated that allelopathic compounds, often considered plant-produced herbicides, can inhibit growth of nearby plants. These compounds could be an alternative weed management strategy for crop production and can offer environmental benefits.

Naseem *et al.,* (2009) stated that today allelopathy is considered as appropriate technology to control weeds applying chemicals released from decomposed plant parts of various species.

Salam and Kato-Noguchi (2010) also stated that roots were more sensitive to the allelochemicals than hypocotyls/coleoptiles cause the roots are the primary organ to absorb allelochemicals from the environment. Moreover, Nishida *et al.,* (2005) stated that the permeability of allelochemicals into root tissue is greater than the shoot tissue.

Xuan *et al.,* (2004) evaluated that liquid extract of neem (*Azadirachta indica*) has phytotoxic potentiality and restrict the growth of *E. crus-galli*, *Monochoria vaginalis* and *Aeschynomene indica*. The osmotic stress imparted by the leaf extracts might lead to the differences in water uptake by the seedlings (Conway *et al.*, 2002).

Belz *et al.,* (2009) conducted a study to investigate whether or not the plant metabolite parthenin is sufficiently persistent, phytotoxic, and bioavailable in soils to cause an allelopathic effect that makes it attributable to the invasive success of the weed *P. hysterophorus*. The aqueous extract of the donor plants resulted a wide range of actions from partial and entire inhibition to stimulation which may show the presence of certain allelochemicals causing inhibition (Qasem, 2002).

Canola extract at 0.1% concentration stimulated redroot pig weed shoot growth compared to water. Germination of redroot pigweed was only inhibited by lentil extracts at 1 and 2%. Root growth was reduced by all extracts at 1 and 2% compared to water but was only reduced by lentil extract at 0.1%. Shoot growth was only reduced compared to water by lentil extract at 2% .Green foxtail germination was not suppressed by any of the extracts. Root growth was suppressed by lentil, canola, and oat extracts at 0.1 %. At 1 % and 2% all extracts suppressed root growth. Shoot growth was not affected by any plant extracts at 0.1% and was only suppressed by lentil extract at 1%. Lentil, canola, and barley extracts at 2% suppressed green foxtail shoot growth (Smith *et al.*, 1999).

2.4 Effect of Chemical Control of Weed Biomass

According to Khan *et al.*, (2011) weed biomass was also significantly influenced by different weed management methods .The highest weed biomass 137.2 and 660 g m^{-2} were obtained from control plot at 25 and 45 DAE, respectively. The lowest weed biomass at 25 DAE obtained from (13.6 g m^{-2}) which was followed by (86 g m^{-2}). At 45 DAE the lowest weed biomass (35.8gm^{-2}) obtained from treatment where Glyphosate spraying was done at minimum tillage condition before 7 days of sowing followed by hand weeding at 25 DAE, which was statistically similar to where Glyphosate spraying was done at no tillage condition before 7 days of sowing followed by hand weeding at 25 DAE. The weed control efficiency by different weed management methods ranged from 7 to 90% and 54 to 95% at 25 and 45 DAE, respectively. At 45 DAE, maximum weed control efficiency (95%) recorded in followed by treatment. The percentage of reduction in weed dry weight per m-2 did not differ among Hammer (16.20 %), Topstar (17.58 %) and Paraxon (17.93 %) but Panida performed better by reducing 34.13 % dry weight over the un weeded control 7 treatment (BARI, 2011). Integrated approach of chemical weeding combined with hand weeding to minimize weed competition in potato field was suggested by Khan *et al.*, (2008).

According to Islam *et al.*, (1989) weed dry matter is a better parameter to measure the competition than the weed number.

Mahajan *et al.*, (2003) observed that application of Pretilachlor alone or in combination with Safener and hand weeding resulted in the lowest total weed density and dry matter and grain yield and number of panicles

CHAPTER III

MATERIALS AND METHODS

In this chapter of the thesis includes a brief description of the experimental period, site selection, laboratory and field condition, treatments, design of the experiment and layout, data collection, and statistical analysis.

3.1 Experimental Period

The experiment was conducted during the period from November 2022 to February 2023.

3.2 Experimental Site

The experiment was conducted at the Department of Agronomy Laboratory at Dr. M.A. Wazed Miah Research Centre and the field experiment was done for the controlling *Sphagneticola calendulacea* at the fellow land of Faculty of Agriculture of Sher-e-Bangla Agricultural University, Dhaka. The site is 90.2°N and 23.50° E Latitude and at an altitude of 8.2 m above from the sea level.

3.3 Experimental Materials

Petri dishes, filter paper, forceps, measuring scale, growth chamber, seed of different crops and weeds were used for this experiment. The following herbicide were used in controlling the weed infestation

1. Filder (2,4-D Amine @ 2.80 L ha-1)
2. Sunup (Glyfhosate @3.70 L ha-1)
3. Weednil 5EC (Quizaloph-P-Ethyle @650 ml ha-1)

3.4 Collection of Seeds

The crop seeds were collected from Siddik Bazar, Dhaka for germination test and also determine the length of root and shoot of the seedlings.

3.5 Collection of the Plant Materials

The *Sphagneticola calendulacea* is a perennial herb that is grown in the gardens, along roadsides, fence rows and in fellow lands of tropical and subtropical regions. The whole plants (except roots) of Sphagneticola calendulacea were collected from the fellow lands of Faculty of Agriculture of Sher-E-Bangla Agricultural University (SAU), Dhaka, Bangladesh in November

2022. The species was identified by Md. Jafar Ullah (Professor, Department of Agronomy) and Sheikh Muhammad Masum (Professor, Department of Agronomy).

3.6 Preparation of Weed Extract

The aqueous extract, prepared from the fresh leaves of the *Sphagneticola calendulacea* plants, was used for this experiment. After washing thoroughly with running tap water to remove the soil and other particles, 100 g of the fresh leaves of the *Sphagneticola calendulacea* were taken into two equal splits (50g+ 50g). The plant parts were crushed into small pieces. After that for solution-1 50g of weed were properly blended with the help of blender machine with the help of distilled water (DW). When blending was done properly the weed extract was poured into a jar and prepare a 500ml solution. For another solution (solution-2) rest of the 50g weed were finely blended with the help of methanol in a blender and prepare a 500ml solution by adding Methanol.

Both of the solutions were kept in the different jar for 48 hours covering with Alumonium foil paper. The solutions were stirred with a glass rod in interval of 12 hours for getting absolute solution. After 48 hours the solution were filtered with a fine cloth. The weed extracts were filtered again onto a single layer of filter paper (A Whatman No.1 filter paper) to prepare desired solutions.

3.7 Treatments and Experimental Design for Alleopathic Effect

The experiment was executed in the year 2022, at Dr. M.A. Wazed Miah Research Centre, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. There were two treatments including leaf extracts of *Sphagneticola calendulacea* with DW (Soln. 1), leaf extracts of *Sphagneticola calendulacea* with methanol (Soln. 2). The treatments were arranged in completely randomized design (CRD) with three replications. The treatments were adopted in natural room light condition homogenously to all the Petri dishes.

The experiment was executed under levels of 5% aqueous solution of 17 selected crops and weed seed. There are-

1. Wheat
2. Jute
3. Rice
4. Chickpeas

5. Peas
6. Cowpea
7. Maize
8. Radish
9. Water Spinach
10. Pumpkin
11. Cucumber
12. Bean
13. Red Amaranth
14. okra
15. Black Eyed Peas
16. Mustard
17. Bilai achra weed

3.8 Data collection

The following data was collected for the test-

- Germination (%)
- Germination Inhibition (%)
- Shoot length
- Root length

3.9 Germination in Petri-dish

Sterilized Petri dishes (9 cm in diameter) were used for the germination test of different crop and weed seeds. . A Whatman No.1 filter paper was kept on the Petri dish moistened with the 5ml of weed extract (Soln. 1), in a petri-dish. For another petri-dish 5ml of weed extract with methanol (Soln. 2) is prepared. And in another petri-dish 5ml Distilled Water is added for the normal condition of seed germination for each of the crop and weed seeds. Ten seeds were placed over each of the Petri-dish and grown for 7 days. The dishes were watered with the DW for getting the favorable moisture content for the growing seeds. Only those seeds with complete radical and plumule emergence are considered to be fully germinated.

3.10 Average Germination Percentage (%)

The germination test was conducted by placing randomly selected 10 seeds in the petri-dish. Germination was considered to have occurred when radicles were 2 mm long (Akbari *et al.*, 2007). Germination progress was inspected and data were collected. The seedlings with short, thick and spiral formed hypocotyls and stunted primary root were considered as abnormally germinated seeds (ISTA, 2003). These types of abnormal or dead seedlings were excluded during counting. At the end of germination test (5 days) Average Germination Percentage was calculated. After that the length of roots and shoots were collected by the help of measuring scale. Total germination (TG) was calculated as the number of seeds which was germinated within total days as a proportion of number of seeds shown in each treatment expressed as a percentage (Othman *et al.*, 2006).

Germination percentage was measured with the following formula:

$$\text{Germination \%} = \frac{\text{Number of germinated seeds}}{\text{Total seeds placed in the petri dish}} \times 100$$

3.11 Germination inhibition (%)

Germination inhibition (%) of the receiver plant was measured by the following formula (Othman *et al.*, 2006).

$$\text{Germination Inhibition (\%)} = 100 - \frac{\text{Germinated seed with treatment solution}}{\text{Germinated seed in control}} \times 100$$

3.12 Preparation of seedlings

The fresh seeds were washed properly and soaked in the water for overnight at room temperature. After that the seeds were ready for the germination test. After germination the length of radicle and plumule were also taken after 5 days of experiment.

3.13 Shoot (plumule) length

After 5 days of conducting experiment, shoot (plumule) length was recorded with a measuring scale carefully and was measured in mm.

3.14 Root (radicle) length

After 5 days of conducting experiment, shoot (radicle) length was recorded with a measuring scale carefully and was measured in mm.

3.15 Collection of weed data

3.15.1 Weed density

The data on weed infestation as well as density were collected from each unit plot at 7 days after the spraying of weedicide. Twelve different plant quadrates of 0.5 m^2 were placed at the experimental site of the plot. Three different quadrates were remained undisturbed randomly for collection of data of weed density and marked as T_0. Average weight of the three quadrates was accepted as weed density. Filder (2,4-D Amine), Sunup 480 SL (Glyphosate), Weednil 5EC (Quizaloph-P-Ethyle) were used as chemical control of *Sphagneticola calendulacea* and these plots were marked as T_1, T_2 and T_3.

3.15.2 Weed biomass

The weeds inside each quadrate for density count were uprooted, cleaned and separated from other species. The weights of the different quadrates are measured by a balance and Average weights of the three quadrates were taken.

3.15.3 Weed control efficiency

Weed control efficiency was calculated with the following formula:

Weed control efficiency was calculated with the following formula:

Weed control efficiency (WCE) = $\frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$

Where,

DWC = Dry weight of weeds without treatment

DWT = Dry weight of weeds in weed control treatment

3.15.4 Relative weed density (%)

Relative weed density was calculated by using the following formula:

Relative weed density (%) = $\frac{\text{Density of individual weed species in the community}}{\text{Total density of all weed species in the community}} \times 100$

3.16 Statistical analysis

The treatment means were separated by using Fisher's Protected Least Significant Difference test with the help of a computer package program named Statistix 10 data analysis software. The Type I error was set at 0.01 for all the statistical comparisons. Standard Errors were calculated by using Microsoft Excel. (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This section contains a presentation and discussion of the study's findings on the allelopathic effect and control of *Sphagneticola calendulacea* plant. The information was presented in various tables and figures. The findings have been discussed below, and possible interpretations were provided under the headings listed below.

4.1 Allelopathic effect on seed germination, radicle and plumule length on different crops and weeds

The process of germination, which is the restart of metabolic process growth by seed tissues, begins with the absorption of water through osmosis and imbibition, which activates enzymes and boosts metabolic activity. The treatment of different types of crops with 5% *Sphagneticola calendulacea* water extract and 5% *Sphagneticola calendulacea* methanolic extract registered a lower germination percentage compared to the control (Table 1). The failure of germination (0%) due to the treatment was found in cowpea, jute, field pea, black eyed pea, rice and bilai achra weed. The inhibitory effect of *Sphagneticola calendulacea* leaf extracts on seed germination might also be due to an imbalance in metabolism regulated by various enzyme activities and other biological factors.

However, the herbicidal activity of flavonoid compounds may be contributing to the further decline in the germination percentage (Javaid *et al.*, 2010; Sorecha and Birhanu, 2017).

Table 1. Allelopathic effect of *Sphagneticola calendulacea* on germination percentage, radicle length, and plumule length of different crops

Name of the Crops	Germination Percentage %			Radicle Length			Plumule Length		
	Control	Water extract	Methanolic extract	Control	Water extract	Methanolic extract	Control	Water extract	Methanolic extract
Wheat	100 ± 1.27	80 ± 1.48	20 ± .13	5.9 ± 1.27	8.87 ± 2.02	.2 ± .13	4.6 ± 1.18	6.28 ± 1.48	.16 ± .15
Jute	100 ± .3	90 ± .49	0	3.9 ± .3	3.45 ± .49	.3 ± .17	4.4 ± .36	4.5 ± .63	0
Rice	100 ± .13	90 ± .36	0	1.65 ± .13	2.87 ± .36	0	2.91 ± .13	2.21 ± .33	0
Chick Peas	50 ± .35	20 ± .18	0	1.87 ± .61	.83 ± .48	0	.85 ± .35	.18 ± .12	0
Peas	90 ± .58	60 ± 1.06	0	4.45 ± .58	2.97 ± 1.06	0	1.98 ± .34	1.14 ± .39	0
Cowpea	90 ± .92	40 ± 1.60	0	5.83 ± .92	2.52 ± 1.03	0	13.73 ± 1.86	3.68 ± 1.61	0
Maize	100 ± .97	60 ± .90	60 ± 1.66	13.66 ± .97	9.22 ± 2.59	5.3 ± 1.66	5.25 ± .51	2.95 ± .91	2.43 ± .72
Radish	100 ± .23	80 ± 2.12	30 ± .60	14 ± 1.23	7.25 ± 2.12	.45 ± .22	7.39 ± .96	6.2 ± 1.26	1.05 ± .6
Water Spinach	100 ± .37	90 ± .88	80 ± .15	4.4 ± .37	3.5 ± .49	.9 ± .15	8.9 ± .29	5.25 ± .88	4.25 ± .96
Pumpkin	90 ± .43	100 ± 1.86	50 ± .13	2.35 ± .43	10.75 ± 1.86	1.45 ± .46	4.45 ± .9	10.95 ± .81	3.8 ± 1.34
Cucumber	100 ± .94	100 ± .62	70 ± .87	11.25 ± .94	7.7 ± .62	3.5 ± .87	9.6 ± .39	9.8 ± .25	8.7 ± 2
Bean	70 ± 1.01	70 ± .88	70 ± 1.03	3.4 ± .7	4.8 ± 1.5	3.82 ± .99	4.45 ± 1.01	3.15 ± .88	3.45 ± 1.03
Red Amaranth	100 ± .32	90 ± .34	30 ± .11	4 ± .32	2.9 ± .35	.33 ± .15	3.35 ± .28	4.8 ± .58	2.2 ± .11
Okra	60 ± .29	40 ± .19	10 ± .15	.8 ± .29	.45 ± .19	.15 ± .11	1.8 ± .61	1 ± .51	.15 ± .15
Black Eyed Pea	80 ± 1.75	40 ± 1.33	0	5.12 ± 1.75	2.3 ± 1.33	0	5.8 ± 1.55	1.93 ± 1.05	0
Mustard	100 ± .67	90 ± .58	80 ± .25	6.9 ± .67	3.65 ± .75	.8 ± 25	4.1 ± .25	4.15 ± .58	1.45 ± .38
Bilai achra weed	60 ± .74	20 ± .38	0	2.71 ± .74	.56 ± .38	0	1.81 ± .51	.82 ± .55	0

Aqueous extract of *Sphagneticola calendulacea* more or less reduced the germination percentage of the following crops and weed seed. In case of Rice, Peas, Okra, Black Eyed Pea, Chick Pea, Cow Pea and Bilai Achra Weed the germination percentage was drastically reduced. On the other hand, Wheat and Cucumber has no change in germination percentage. It is also needed to be mentioned that, Pumpkin showed higher germination percentage with *Sphagneticola calendulacea* methanolic extract than normal condition.

In presence of Aqueous extract of *Sphagneticola calendulacea* Jute, Chick pea, Peas, Cow Pea, Water Spinach, Maize, Radish, Cucumber, Red Amaranth, Okra, Black Eyed Peas, Mustard, Bilai Achra the length of radicle drastically reduced. Whereas, the length of radicle increase in case of Wheat, Rice, Pumpkin and Bean.

In this instance, the length of plumule decrease in Rice, Maize, Peas, Radish, Winter Spinach, Bean, Bilai Achra and Okra 24%, 43%, 73%, 16%, 41%, 29%, 55% and 44%, respectively. Whereas, the length of plumule increase of Wheat, Jute, Cucumber, Mustard and Pumpkin 36%, 5%, 3%, 13% and 146%, respectively.

Aqueous extract of *Sphagneticola calendulacea* with Methanol drastically reduced the germination percentages of all crops seed. Rice, Peas, Black Eyed Pea, Chick Pea, Cow Pea and Bilai Achra Weed showed no germination in presence of Methanol with *Sphagneticola calendulacea* extract. In case of Bean, germination percentage has no change in presence of methanol with *Sphagneticola calendulacea* plant extract.

Sphagneticola calendulacea extract In accordance with Methanol severly affect in radicle emergence of Rice, Chick Pea, Cow Pea, Black Eyed Pea and Peas. In this experiment it showed 0% root emergence. Other crop seeds showed slightly emergence of radicle. No seedlings showed more radicle length than control condition.

The emergence of plumule was not occurred in case of Rice, Jute, Peas and Bilai Achra weed plant. The other crop plant like Wheat, Bean, Okra, Mustard, Red Amaranth, Maize, Radish, Water Spinach and Pumpkin also showed 96%, 11%, 91%, 58%, 33%, 53%, 86%, 51% and 13%, respectively.

4.2 Allelopathic effect of radicle and plumule length on different crop seeds

4.2.1 Allelopathic effect of radicle and plumule length on wheat

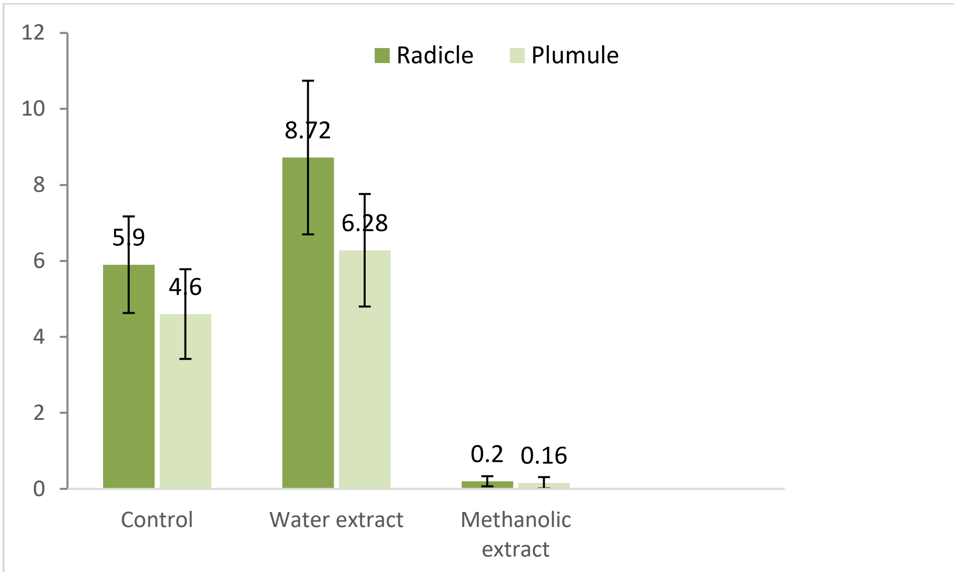

Figure 1. Allelopathic effect of *Sphagneticola calendulacea* on radicle length and plumule length of wheat

The experiment involved treating wheat plants with different substances to observe their effects on growth. The control group, which received distilled water, showed average radicle (root) and plumule (shoot) lengths of 5.9 cm and 4.6 cm, respectively.

When the wheat plants were exposed to a weed extract, their growth was enhanced. The average radicle and plumule lengths increased to 8.72 cm and 6.28 cm, respectively, indicating a positive stimulation of root and shoot growth.

However, when methanol was added to the weed extract treatment, it had a detrimental impact on the wheat plants. The average radicle length decreased significantly to 0.2 cm, while the plumule length was severely inhibited at only 0.16 cm.

To summarize, the weed extract treatment had a beneficial effect on the growth of wheat plants, promoting root and shoot development. However, the addition of methanol to the weed extract resulted in stunted growth, with a notable reduction in both radicle and plumule lengths.

4.2.2 Allelopathic effect of radicle and plumule length on jute

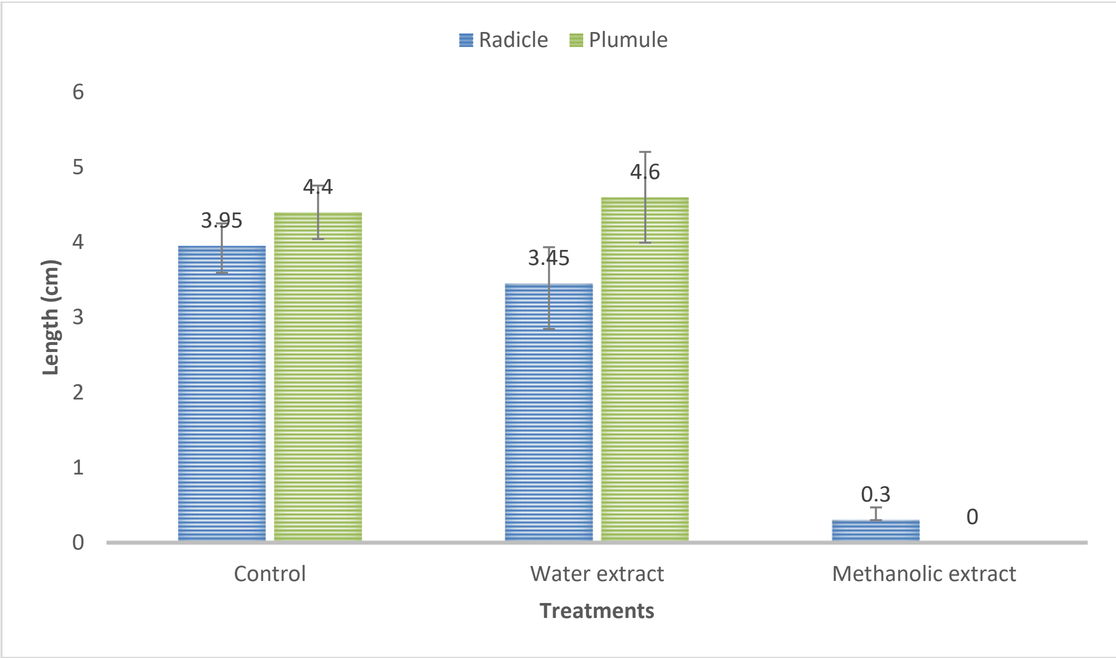

Figure 2. Allelopathic effect *of Sphagneticola calendulacea* on radicle length and plumule length of jute

These measurements represent the average lengths observed for the jute roots and shoots after exposure to each treatment. The results indicate the effects of the treatments on the growth of jute plants.

In the control group treated with distilled water, the average radicle length was 3.95 cm, reflecting the natural growth of jute roots in the absence of additional treatments. The average plumule length was 4.4 cm, indicating the shoot growth under normal conditions.

In the weed extract treatment group, the jute plants displayed slightly reduced radicle and plumule lengths compared to the control group. The average radicle length was 3.45 cm, suggesting a minor inhibitory effect on root growth. The average plumule length was 4.5 cm, indicating a slight reduction in shoot growth.

When methanol was combined with the weed extract in the treatment group, the jute plants showed significantly stunted growth. The average radicle length was only 0.3 cm, indicating a substantial inhibitory effect on root growth. Additionally, the average plumule length was 0 cm, suggesting complete inhibition of shoot growth.

In summary, the weed extract treatment had a limited effect on the radicle and plumule lengths of jute plants, with slight reductions compared to the control group. However, the addition of methanol to the weed extract severely inhibited both root and shoot growth, resulting in significantly stunted jute plants. These findings suggest that the presence of methanol in the weed extract has a detrimental impact on the growth and development of jute plants.

4.2.3 Allelopathic effect of radicle and plumule length on rice

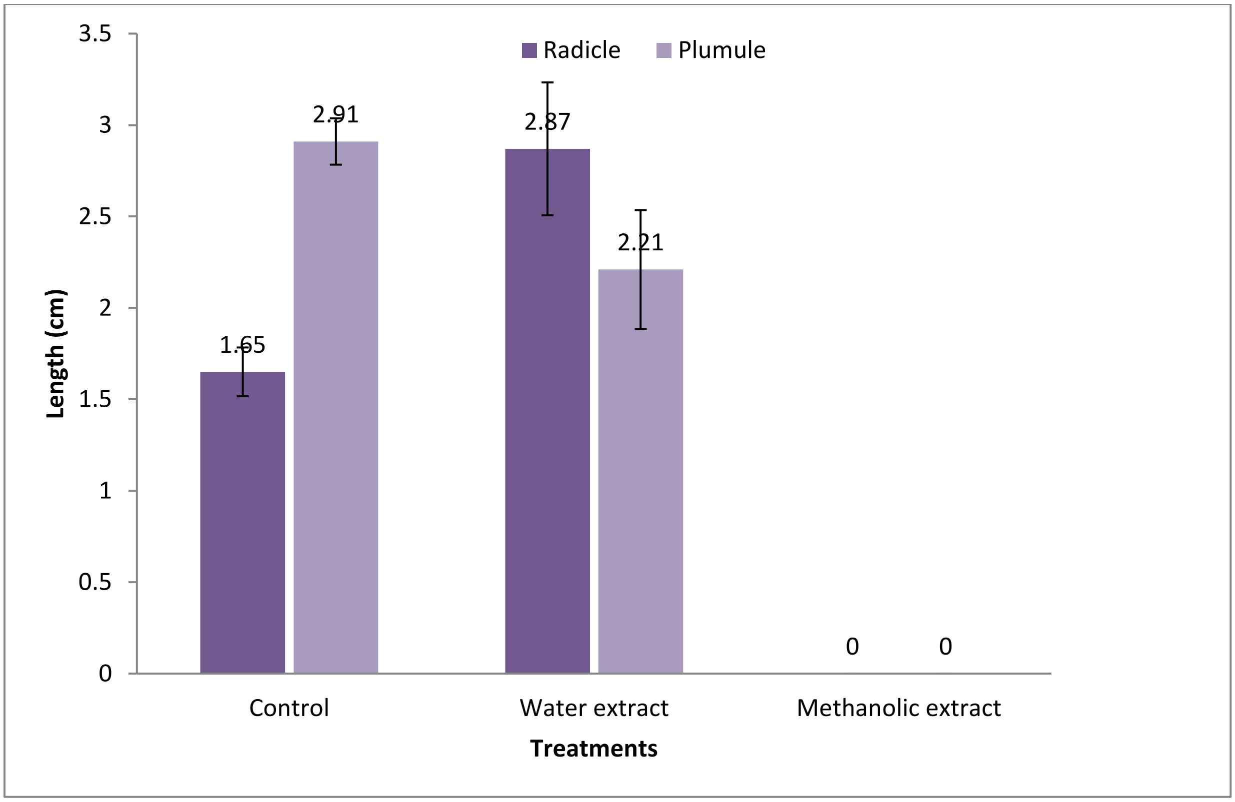

Figure 3. Allelopathic effect of *Sphagneticola calendulacea* on radicle length and plumule length of rice

In the control group treated with distilled water, the average radicle length was 1.65 cm, reflecting the natural growth of rice roots in the absence of additional treatments. The average plumule length was 2.91 cm, indicating the shoot growth under normal conditions.

In the weed extract treatment group, the rice plants displayed an increase in both radicle and plumule lengths compared to the control group. The average radicle length was 2.87 cm, suggesting a stimulation of root growth. The average plumule length was 2.21 cm, indicating a slight reduction in shoot growth compared to the control group.

When methanol was combined with the weed extract in the treatment group, the rice plants showed no visible radicle or plumule growth. Both radicle length and plumule length were measured as 0 cm, indicating a complete inhibitory effect on root and shoot growth.

In summary, the weed extract treatment had a stimulatory effect on both radicle and plumule lengths of rice plants, promoting their growth compared to the control group. However, when methanol was added to the weed extract, it resulted in a complete inhibition of root and shoot growth. These findings suggest the presence of bioactive compounds in the weed extract that can positively influence the growth and development of rice plants, but the addition of methanol counteracts these effects.

4.2.4 Allelopathic effect of radicle and plumule length on maize

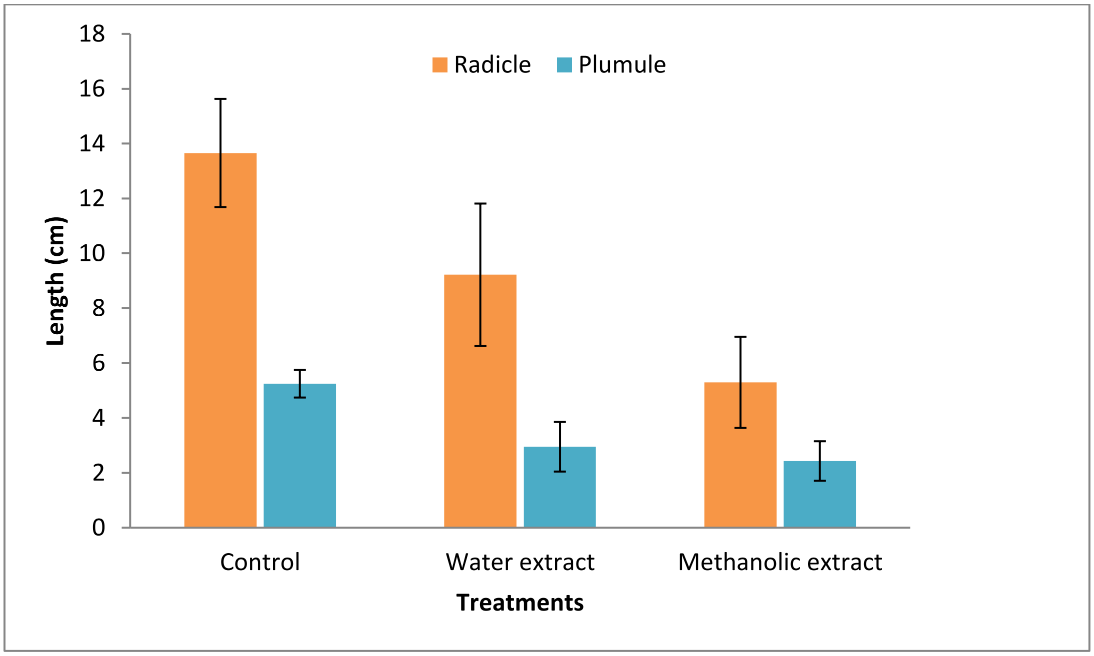

Figure 4. Allelopathic effect of *Sphagneticola calendulacea* on radicle length and plumule length of maize

These measurements represent the average lengths observed for the maize roots and shoots after exposure to each treatment. The results indicate the effects of the treatments on the growth of maize plants.

In the control group treated with distilled water, the average radicle length was 13.66 cm, reflecting the natural growth of maize roots in the absence of additional treatments. The average plumule length was 5.25 cm, indicating the shoot growth under normal conditions.

In the weed extract treatment group, the maize plants displayed a decrease in both radicle and plumule lengths compared to the control group. The average radicle length was 9.22 cm, suggesting an inhibitory effect on root growth. The average plumule length was 2.95 cm, indicating a reduction in shoot growth.

When methanol was combined with the weed extract in the treatment group, there was a further decrease in both radicle and plumule lengths. The average radicle length was 5.3 cm, indicating a more pronounced inhibitory effect on root growth. The average plumule length was 2.43 cm, suggesting a continued reduction in shoot growth.

In summary, the weed extract treatment had an inhibitory effect on both radicle and plumule lengths of maize plants, reducing their growth compared to the control group. The addition of methanol to the weed extract further intensified this inhibitory effect, resulting in shorter roots and shoots. These findings indicate the potential allelopathic activity of the weed extract on maize plants, suggesting the presence of bioactive compounds that negatively influence their growth and development.

4.2.5 Allelopathic effect of radicle and plumule length on pumpkin

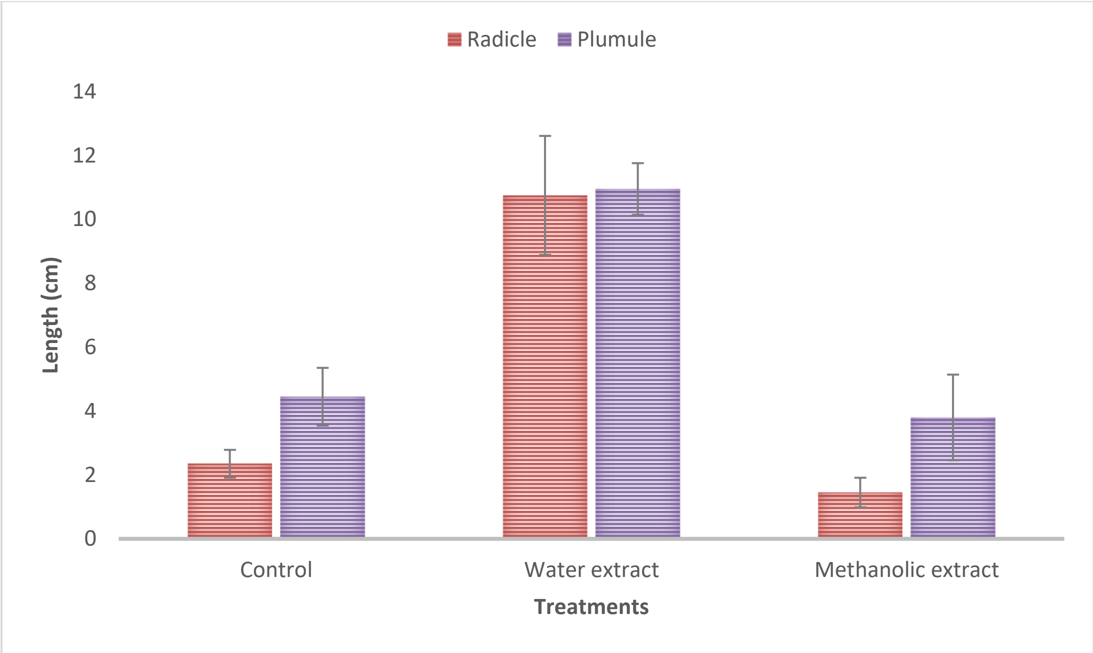

Figure 5. Allelopathic effect of *Sphagneticola calendulacea* on radicle length and plumule length of pumpkin

These measurements represent the average lengths observed for the pumpkin roots and shoots after exposure to each treatment. The results indicate the effects of the treatments on the growth of pumpkin plants.

In the control group treated with distilled water, the average radicle length was 2.35 cm, reflecting the natural growth of pumpkin roots in the absence of additional treatments. The average plumule length was 4.45 cm, indicating the shoot growth under normal conditions.

In the weed extract treatment group, the pumpkin plants displayed a substantial increase in both radicle and plumule lengths. The average radicle length was 10.75 cm, suggesting a significant stimulation of root growth compared to the control group. The average plumule length was 10.95 cm, indicating a considerable enhancement of shoot growth.

However, when methanol was combined with the weed extract in the treatment group, there was a notable decrease in both radicle and plumule lengths. The average radicle length was 1.45 cm, indicating a significant inhibitory effect on root growth. The average plumule length was 3.8 cm, suggesting a pronounced inhibition of shoot growth.

In summary, the weed extract treatment had a stimulating effect on both radicle and plumule lengths of pumpkin plants, promoting their growth. However, when methanol was added to the weed extract, it resulted in a significant reduction in both root and shoot lengths, indicating an inhibitory effect on overall plant growth. These findings highlight the potential allelopathic activity of the weed extract on pumpkin plants, indicating the presence of bioactive compounds that influence their growth and development.

4.2.6 Allelopathic effect of radicle and plumule length on cucumber

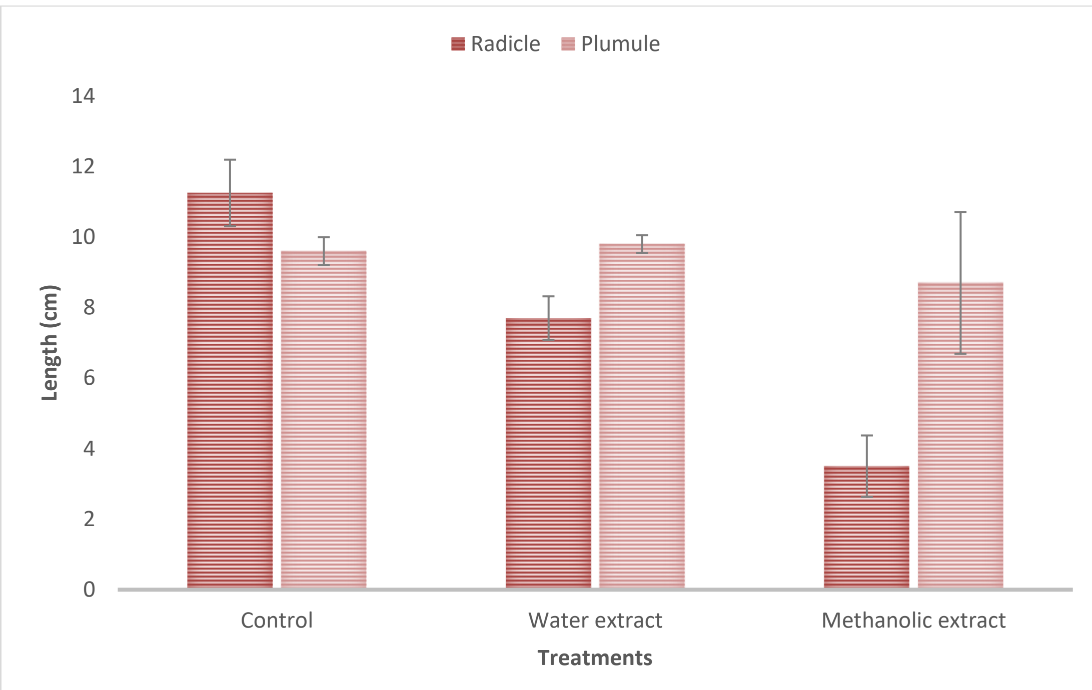

Figure 6. Allelopathic effect of *Sphagneticola calendulacea* on radicle length and plumule length of cucumber

The results demonstrate that the weed extract treatment had a minor inhibitory effect on cucumber root growth, while shoot growth was not significantly affected. However, when methanol was combined with the weed extract, there was a substantial decrease in both radicle and plumule lengths, indicating a more pronounced inhibitory effect on overall plant growth. These findings suggest the potential allelopathic activity of the weed extract, which may contain bioactive compounds that influence the growth and development of cucumber plants.

4.2.7 Allelopathic effect of radicle and plumule length on mustard

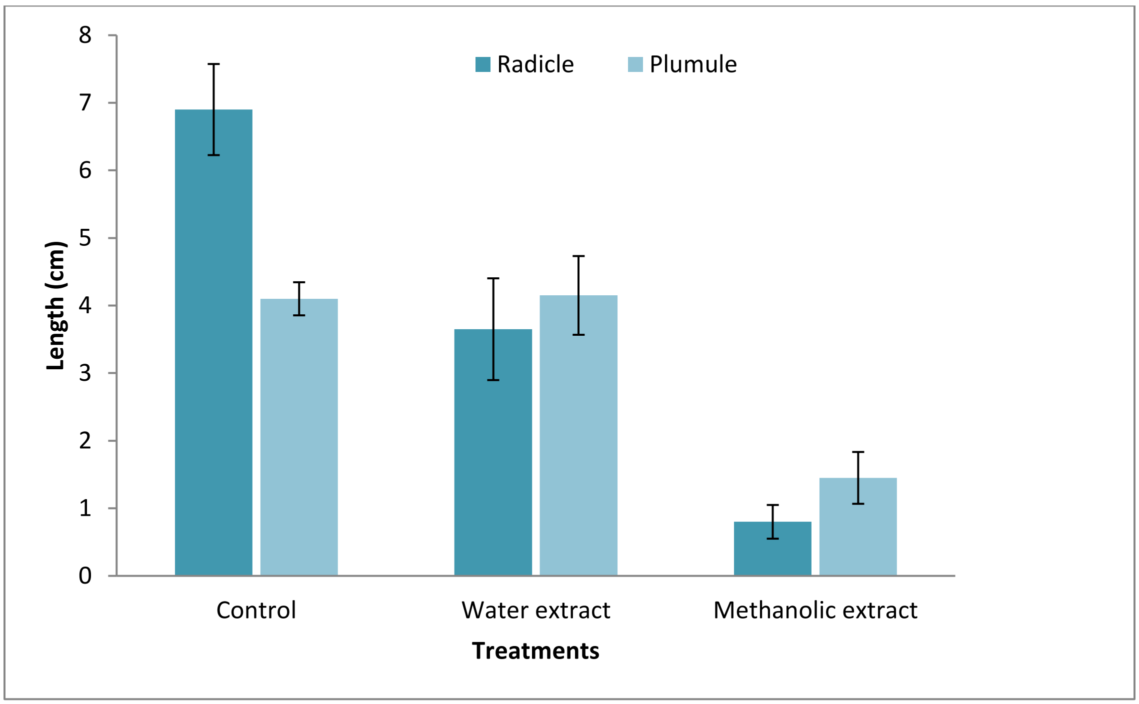

Figure 7. Allelopathic effect of *Sphagneticola calendulacea* on radicle length and plumule length of mustard

Based on the data, the distilled water treatment (control group) exhibited the highest radicle length of 6.9 cm, while the weed extract treatment showed a reduced radicle length of 3.65 cm. The weed extract mixed with methanol treatment had the lowest radicle length of 0.8 cm.

In terms of plumule length, both the control group and the weed extract treatment demonstrated similar values, with 4.1 cm and 4.15 cm respectively. The weed extract mixed with methanol treatment resulted in the lowest plumule length of 1.45 cm.

These results suggest that the weed extract, possibly containing allelochemicals from *Sphagneticola calendulacea*, had an inhibitory effect on the radicle growth of mustard plants. The addition of methanol to the weed extract further intensified this inhibition. However, the plumule growth of the mustard plants was relatively unaffected by the treatments, except for a slight reduction in the weed extract mixed with methanol treatment.

It is important to note that these results are based on the provided dataset and further experimentation and statistical analysis would be necessary to draw more conclusive findings.

4.2.8 Allelopathic effect of radicle and plumule length on chickpea

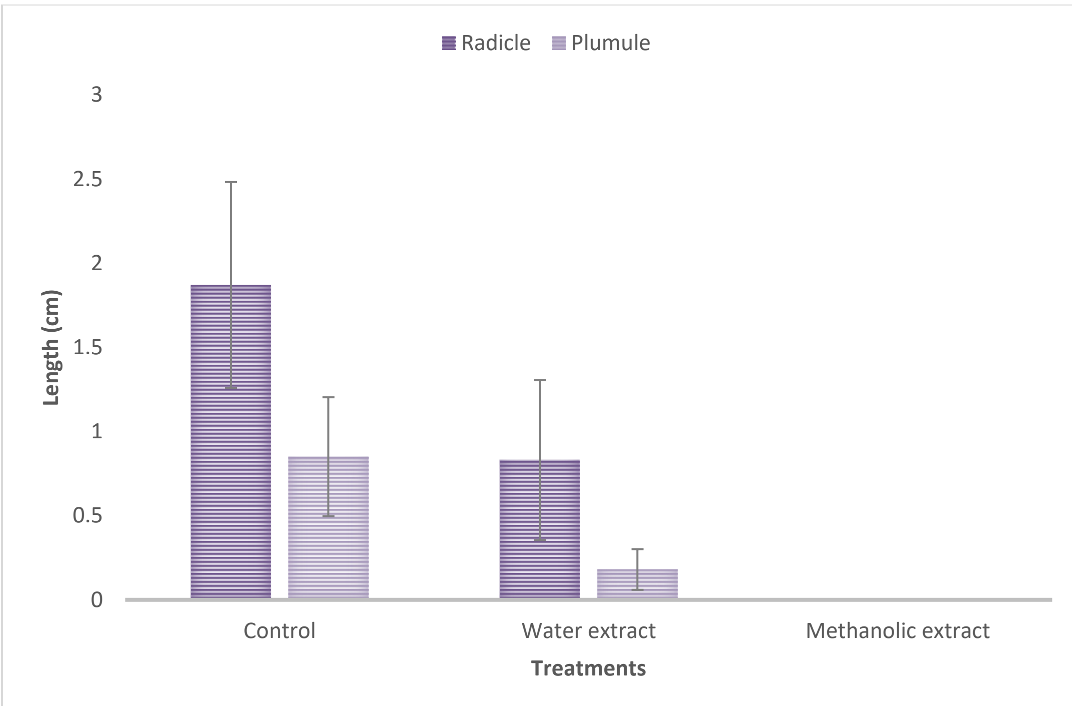

Figure 8. Allelopathic effect of *Sphagneticola calendulacea* on radicle length and plumule length of chickpea

These measurements represent the average lengths observed for the chickpea roots and shoots after exposure to each treatment. The results indicate the effects of the treatments on the growth of chickpea plants.

In the control group treated with distilled water, the average radicle length was 1.87 cm, reflecting the natural growth of chickpea roots in the absence of additional treatments. The average plumule length was 0.85 cm, indicating the shoot growth under normal conditions.

In the weed extract treatment group, the chickpea plants displayed a decrease in both radicle and plumule lengths compared to the control group. The average radicle length was 0.83 cm, suggesting an inhibitory effect on root growth. The average plumule length was 0.18 cm, indicating a significant reduction in shoot growth.

When methanol was combined with the weed extract in the treatment group, the chickpea plants showed no radicle or plumule growth. Both radicle length and plumule length were measured as 0 cm, indicating a severe inhibitory effect on root and shoot growth.

In summary, the weed extract treatment had an inhibitory effect on both radicle and plumule lengths of chickpea plants, reducing their growth compared to the control group. The addition of methanol to the weed extract intensified this inhibitory effect, resulting in no visible growth of roots or shoots. These findings suggest the presence of bioactive compounds in the weed extract that negatively impact the growth and development of chickpea plants.

4.3 Germination Inhibition (%)

The seeds imbibed with aqueous *Sphagneticola calendulacea* leaf extract and aqueous extract with methanol delayed and inhibited the germination, radicle growth, and plumule growth in comparison to the control which was highly significant ($p < 0.01$). In presence of methanol germination inhibition became high.

4.3.1 Germination Inhibition (%) in Aqueous Extract of *Sphagneticola calendulacea*

Table 2. Germination Inhibition (%) in Aqueous Extract of *Sphagneticola calendulacea*

Name of the Crops	Germination Inhibition (%)	Name of the Crops	Germination Inhibition (%)
Wheat	20	Pumpkin	-11.11
Jute	10	Cucumber	0
Rice	10	Bean	0
Chickpea	60	Red Amaranth	10
Peas	66.67	Okra	66.66
Cowpea	55.55	Black Eyed Pea	50
Maize	40	Mustard	10
Radish	20	Bilai achra weed	66.66
Water Spinach	10		

The highest inhibition (66.66%) in seed germination of Pea, Okra and Bilai Achra Weed whereas the lowest (0%) inhibition was found in Cucumber and Bean which was statistically similar to Rice, Water Spinach, Jute, Red Amaranth and Mustard germination inhibition (10%). Pumpkin has a germination promontory effect on the aqueous extract of *Sphagneticola calendulacea*

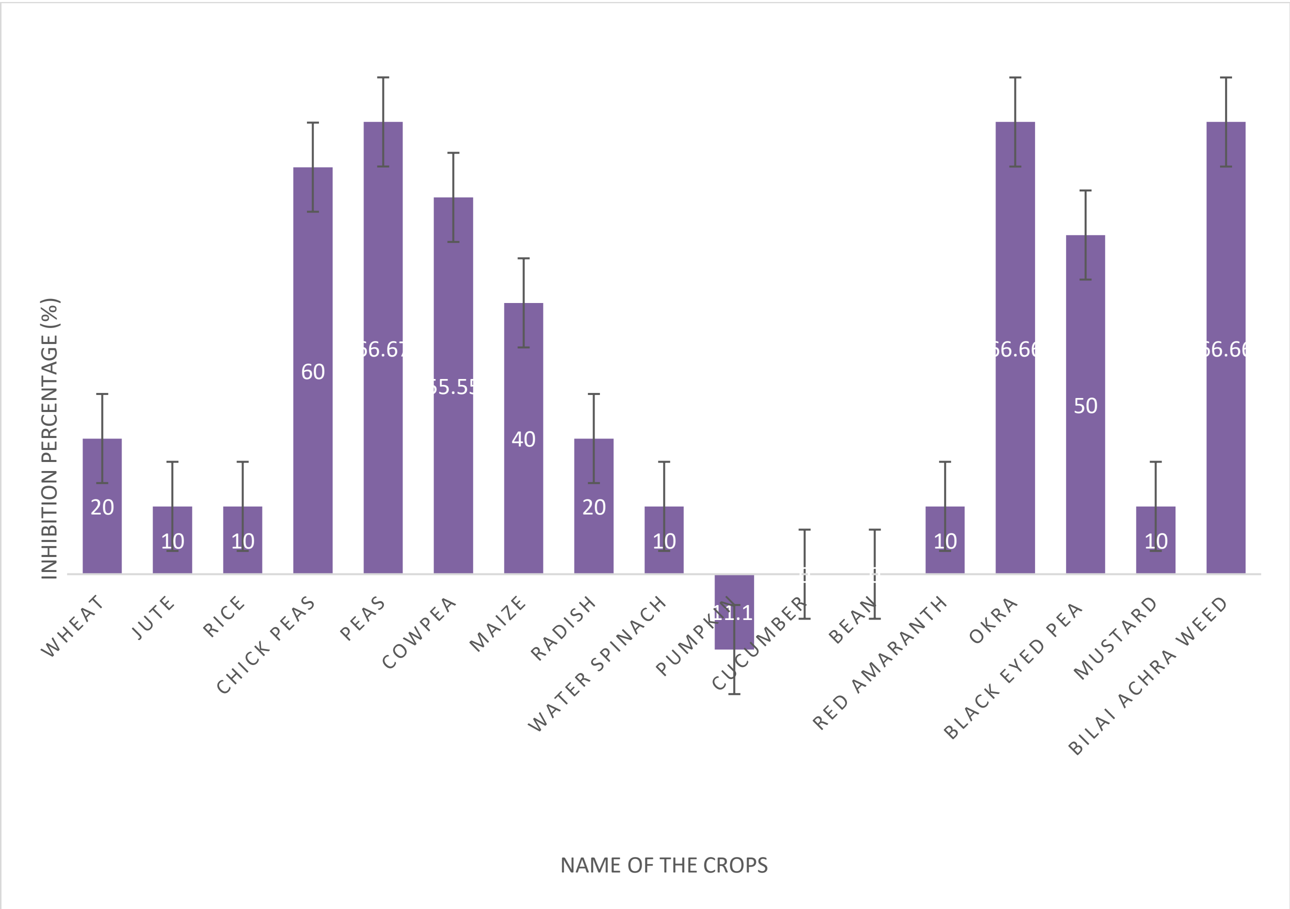

Figure 9. Germination inhibition potential of the aqueous extracts of *Sphagneticola calendulacea* on different crop seeds

4.3.2 Germination Inhibition (%) in Aqueous Extract of *Sphagneticola calendulacea* with Methanol

Table 3. Germination Inhibition (%) in Aqueous Extract of *Sphagneticola calendulacea*

Name of the Crops	Germination Inhibition (%)	Name of the Crops	Germination Inhibition (%)
Wheat	80	Pumpkin	44.44
Jute	100	Cucumber	30
Rice	100	Bean	0
Chick Peas	100	Red Amaranth	70
Peas	100	Okra	83
Cowpea	100	Black Eyed Pea	100
Maize	40	Mustard	20
Radish	70	Bilai achra weed	100
Water Spinach	20		

The highest inhibition (100%) in seed germination of Jute, Rice, Peas, Cowpeas, Chickpea, Black eyed Peas and Bilai Achra Weed. Whereas the lowest (0%) inhibition was found in Bean which was statistically similar to Water Spinach and Mustard germination inhibition (20%).

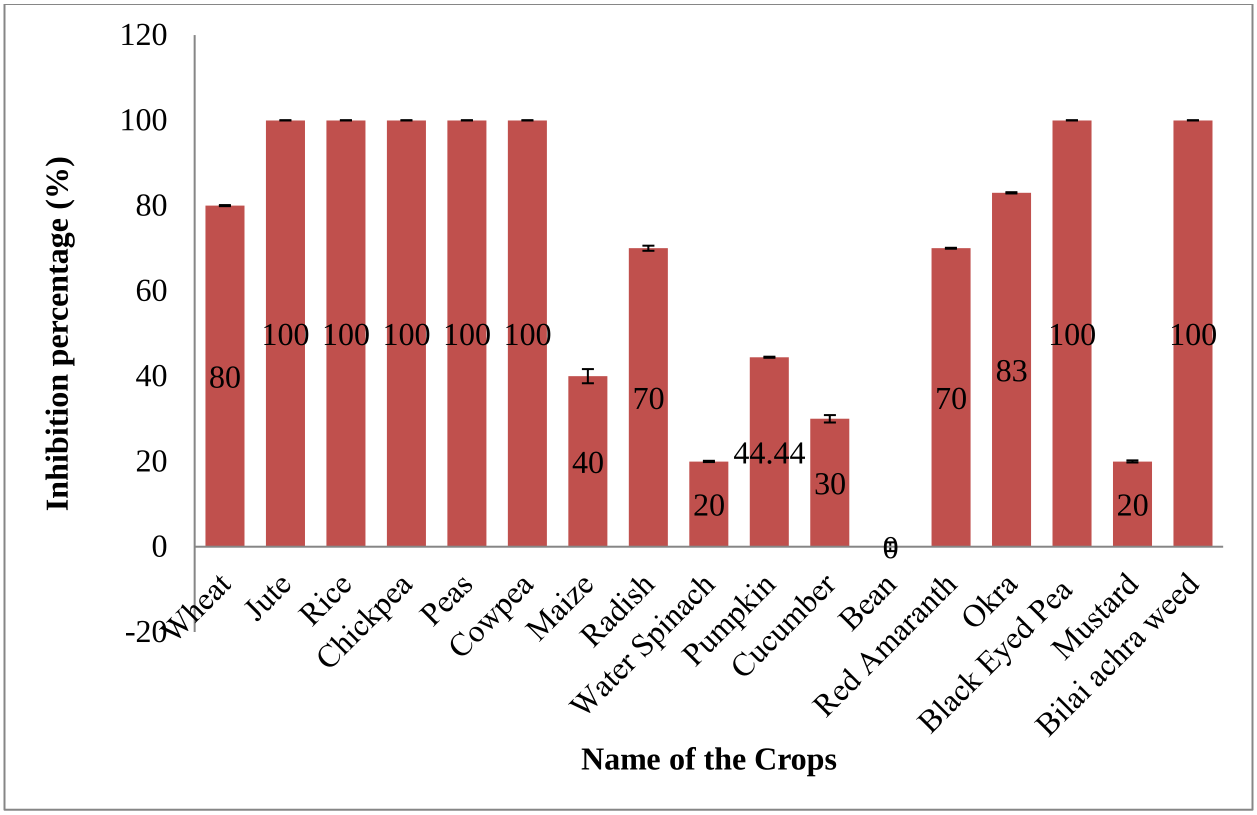

Figure 10. Germination inhibition potential of the aqueous extracts from *Sphagneticola calendulacea* extract with Methanol on different crop seeds

4.4 Control of *Sphagneticola calendulacea*

Sphagneticola calendulacea can be controlled in both mechanical and chemical control of weed. Though it is a broadleaf weed it can be controlled easily by hand weeding. But hand weeding is time consuming and has a high cost of labor, and randomly grow in fallow land and roadsides. So it can be controlled easily by using weedicide. In a field experiment followed by Completely Randomized Block Design (CRD) the following result was found.

4.4.1 Weed Biomass

The total weed biomass determined in the experiment was 653g, 342g, 603g and 601g in T_0, T_1, T_2 and T_3 respectively in 0.25m^2 sized plots of a land. T_0 was considered as control in the experiment. In T_1 lowest biomass was obtained 10 days after spraying weedicide. In T_2 and T_3 total biomass were more or less same and had slightly effect on the reduction of weed biomass. Whereas, T_1 had highest effect on the reduction of total biomass production.

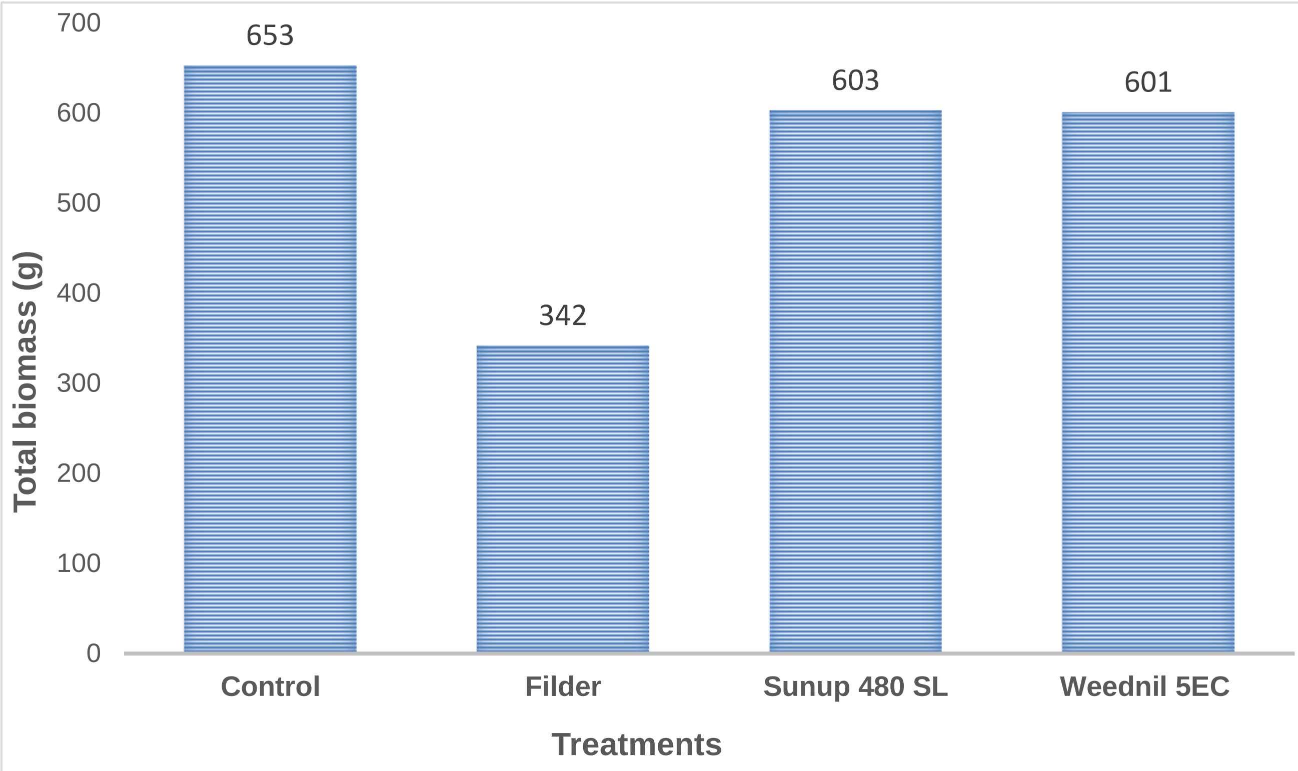

Figure 11. Total biomass of *Sphagneticola calendulacea* spraying weedicide after 10 days

4.4.2 Weed Control Efficiency (WCE)

Filder (2,4-D Amine) had the highest (47.6%) weed control efficiency. Whereas the weed control efficiency of Sunup 480 SL (Glyfoset) and Weednil 5EC (Quizaloph-P-Ethyle) had same weed control efficiency 7.66% and 8% respectively 10 days after spraying weedicide. Filder had 40% and 39% more weed control efficiency than Sunup and Weednil respectively.

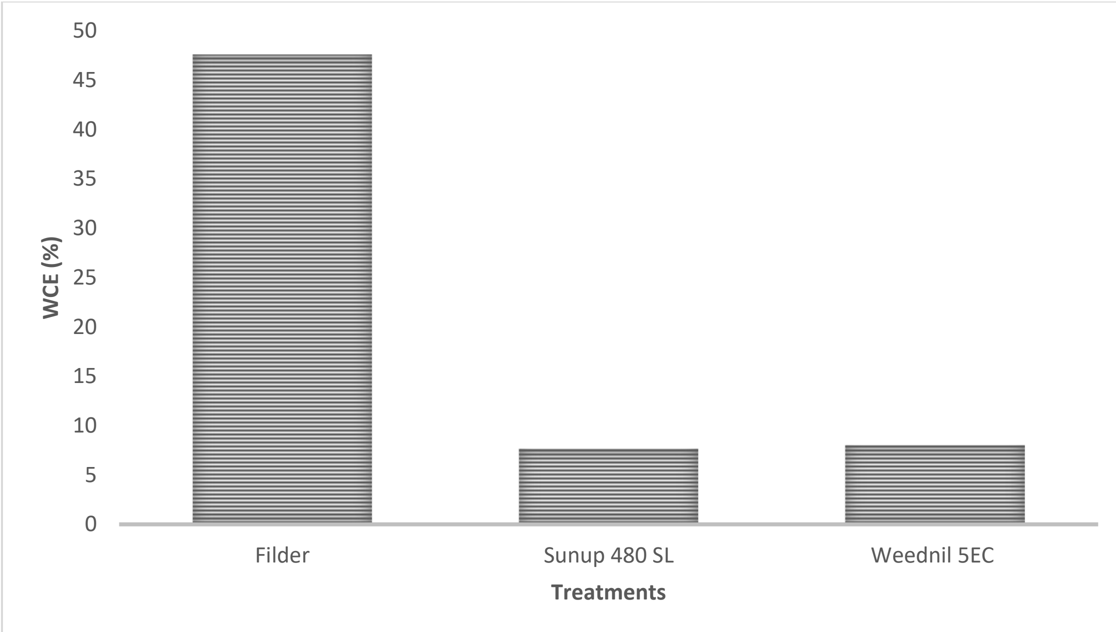

Figure 12. Weed Control Efficiency (WCE) of *Sphagneticola calendulacea* spraying weedicide after 10 days

4.4.3 Weed Density

Sphagneticola calendulacea is highly invasive and dense weed migrated in Bangladesh from China. Though it has a strong allelopathic effect on the surrounding plants and other biomass, it has a high density. In the field experiment T_0 was not treated by any weedicide. In this plot ($0.25m^2$) of the experimental site 653g of the total weed biomass was obtained. So, the density of the weed obtained in the experiment was 2.6 kg/m^2.

4.4.4 Relative Weed Density

This experiment showed that *Sphagneticola calendulacea* has high density for its invasive and alleopathic effect. It releases various phytochemicals in the surrounding environment. For this nature of the weed other plants and weeds don’t grow its surrounding. In this experiment the Relative Weed Density was found 98.94% which shows that it has higher density than most other weed and its invasiveness is dangerous for other crops and weeds also.

CHAPTER V

SUMMARY AND CONCLUSION

Sphagneticola calendulacea (*Sphagneticola calendulacea* L.) family Asteraceae commonly called *Sphagneticola calendulacea*, Chinese Daisy Singapore Daisy is a foreign invasive herbaceous weed, native to the tropical and subtropical regions but now distributed worldwide. An experiment was conducted during November 2022 to February 2023 in Sher-e-Bangla Agricultural University, Dhaka to demonstrate the allelopathic effect of *Sphagneticola calendulacea* and to identify the chemical control of this weed. The determination of allelopathic effect was done in the laboratory and control of the weed in fellow land. Wheat, Jute, Rice, Chick Peas, Peas, Cowpea, Maize, Radish, Water Spinach, Pumpkin, Cucumber, Bean, Red Amaranth, Okra, Black Eyed Peas, Mustard and Bilai Achra Weed seed were used for the determination of germination and inhibition of these seeds.

Sphagneticola calendulacea has been stated to be a highly allelopathic species and this trait has been suggested to be highly important in invasion and persistence in a wide range of local and alien ecosystems. *Sphagneticola calendulacea* contains potential allelochemicals within its aerial parts (e.g. leaves,stems). Subsequently, a laboratory experiment was conducted using a 5% aqueous solution of *Sphagneticola calendulacea*, 5% aqueous solution of *Sphagneticola calendulacea* with Methanol along with distilled water that served as a control. During the laboratory study, data were recorded on germination percentage (%), and radicle and plumule length of each plant (cm). The study demonstrated that leaf aqueous extracts of *Sphagneticola calendulacea* exhibited significant inhibitory effects on seed germination and seedling growth of all tested crops including major cereals, pulses, oilseeds, fiber, and vegetables. But in the case of Pumpkin and cucumber the length of radicle and plumule was higher than control. Whereas in the condition of methanolic extract severely affects the germination percentage (%) and the length of radicles and plumule.

The complete failure of germination (%) due to the treatment of *Sphagneticola calendulacea* water extract and 63% in case of Methanol with weed extract was found this experiment. Among the major cereals, Maize had the lowest germination percentage (40%) followed by wheat (80%) and rice, mustard and jute (90%) with aquas extract of *Sphagneticola calendulacea*. In the case of peas, chickpeas, black eyed peas and cowpeas the percentage of germination drastically reduced to 50%, 20%, 40% and 30% respectively. Whereas, germination percentage was 10% more than control condition in Pumpkin and normal with Cucumber.

In presence of methanolic extract, the germination percentage of all crops drastically reduced. In the case of major cereal crops rice and jute showed 0% germination, maize and wheat showed 60% and 20% germination respectively in respect of control condition where all the crops showed 100% germination. In case of other crops like Red Amaranth presents lowest germination percentage (10%) difference than control condition. Chick Peas, Peas, Cow Pea, Radish, Water Spinash, Pumpkin, Cucumber, , Okra, Black Eyed Peas, Mustard, Bilai Achra weed showed 50%, 90%, 90%, 70%, 50%, 40%, 30%, 50%, 80%, 80%, 40%, 60% lower germination than control condition. Country Bean showed no fluctuation in respect of germination in presence of methanolic extract.

Aqueous extract of *Sphagneticola calendulacea* drastically reduced the radicle and plumule length of germinated seeds without creals. The results showed that radicle and plumule length of Maize increased at 33% and 43%, respectively different from that of the control. The radicle and plumule length of Wheat increased at 48% and 37%, respectively were different from that of the control. The radicle and plumule length of Rice increased at 70% and 30%, respectively different from that of the control. Whereas in Jute, radicle length decreased at 12% and plumule length increased at 5% were different from that of the control. The germinated mustard seed's radicle and plumule were 55% decreased and 5% increased respectively different as compared to the mustard control seedlings. In case of Chickpea, Peas, Cowpea, Radish, Water Spinach, Okra, Black Eyed Peas the radicle length decreased at 87%, 33%, 56%, 51%, 21%, 50%, 55% respectively and the length of plumule also decreased at 102%, 42%, 73%, 16%, 41%, 45% and 66% respectively than control condition. In case of Cucumber and Red Amaranth the length of radicle decreased at 31% and 27% respectively. But the plumule length increased at 2% and 43% respectively than control condition. Whereas, Country Bean showed 41% increased radicle length and 29% decreased in plumule length. Bilai Achra Weed showed 79% and 55% decrease in radicle and plumule length than control condition which was treated with only distilled water. Most importantly Pumpkin showed increase in radicle and plumule length at 357% and 146% respectively. Among the major crops like Wheat, Maize, Rice and Jute Maize showed reduction in both radicle and plumule length, whereas, Rice and Wheat showed increased in both radicle and plumule length. Jute showed decrease in radicle length and increase in plumule length.

Methanolic extract of *Sphagneticola calendulacea* showed drastic reduction of radicle and plumule length than the control condition. In maize, wheat, jute the radicle length decreased at 61%, 96% and 92% than the control condition. In respect of Rice seed there is no emergence of root and shoot in presence of Methanol with *Sphagneticola calendulacea* weed. Chickpea, Cowpea, Fieldpea, Black eyed peas and Bilai Achra weed also showed no emergence of radicle and plumule in that condition. Radish, water spinach, pumpkin, cucumber, red amaranth, okra, mustard showed 96%, 80%, 38%, 68%, 91%, 81% and 95% decrease in radicle and 85%, 52%, 14%, 9%, 94%, 91% and 64% decrease in plumule length than the control condition. Whereas Country Bean showed 12% increase in radicle length and 29% decrease in plumule length.

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Radicle appeared more sensitive to allelopathic effect than plumule in most cases of test species. *Sphagneticola calendulacea* is known to have drastic impacts on agricultural productivity and sustainability. However, little information is available on its direct impacts on agriculture, especially in tropical and subtropical region. The information presented in this research demonstrates that *Sphagneticola calendulacea* is a very invasive weed species shown in the Bangladesh as well as other tropical and subtropical region. The adverse impacts of *Sphagneticola calendulacea* aqueous extracts with methanol on the growth of test crops could be attributed to the presence of various phytotoxic compounds in *Sphagneticola calendulacea*. Thus, the present findings suggest preventing *Sphagneticola calendulacea* infestation around the fallow lands, road sides, crop fields and pastures which could be affected by the allelochemicals released by *Sphagneticola calendulacea*. The agricultural impacts of *Sphagneticola calendulacea* are multilateral and therefore require dynamic broad-spectrum solutions. Preventive measures are important to check for new infestations in cropping areas. In this situation Filder (2,4-D Amine) can effectively control this invasive weed. Hand weeding may be effective in small scale but for large scale control of *Sphagneticola calendulacea* chemical control of *Sphagneticola calendulacea*. The integrated management strategies involving chemical, biological, and mechanical control methods are likely to be the most effective. However, proper legislation and policy-making, and coordination of management to help control *Sphagneticola calendulacea* in Bangladesh are necessary.

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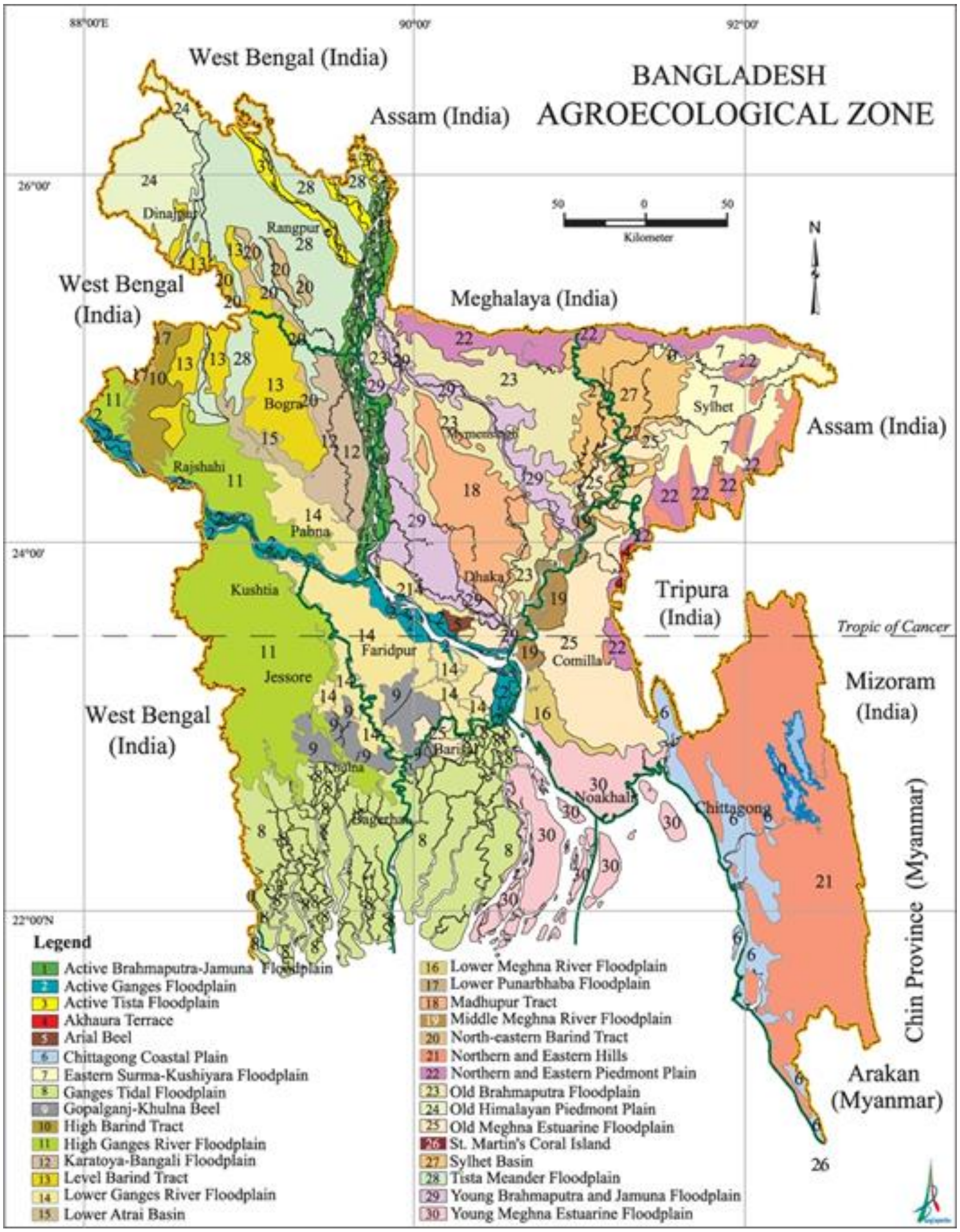
APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	Characteristics
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
Soil series	Tejgaon
Topography	Fairly leveled

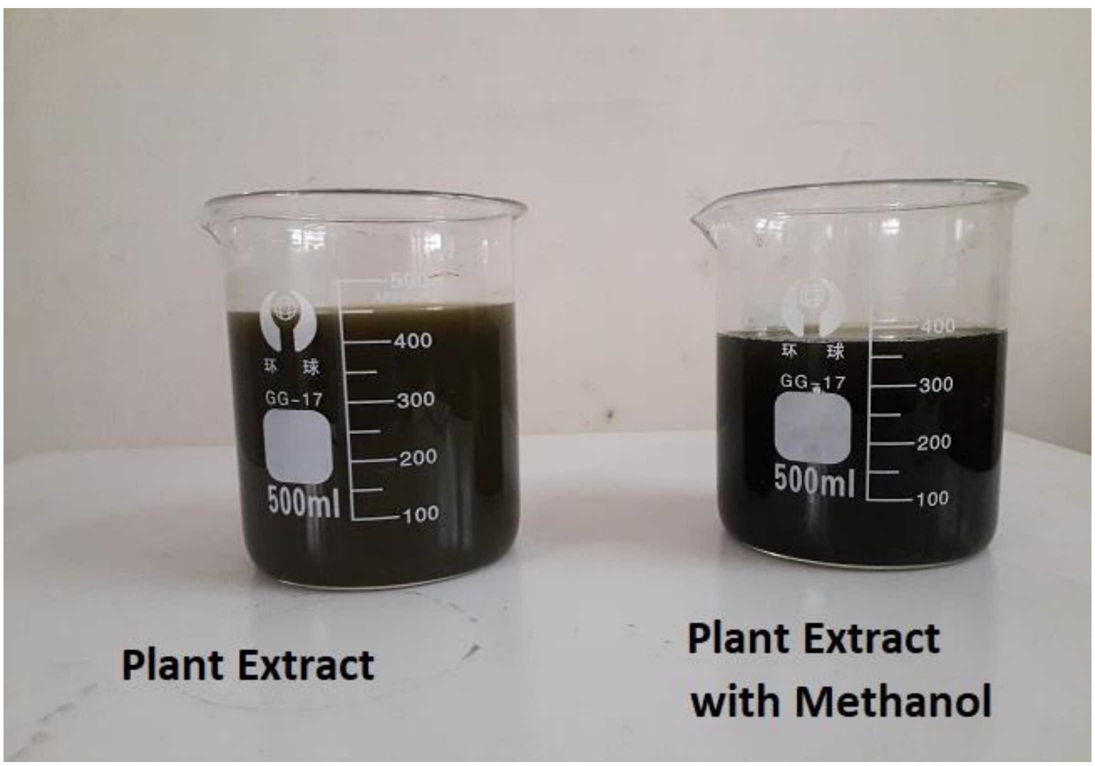
B. The initial physical and chemical characteristics of soil of the experimental site (0- 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Clay	29 %
Sand	26 %
Silt	45 %
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10
Organic carbon (%)	0.45
Organic matter (%)	0.78
pH	5.6
Total nitrogen (%)	0.03

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

Appendix III. Pictures of the Experiment

Sphagneticola calendulacea infestation in fallow land



5% aqueous solution of *Sphagneticola calendulacea*

Plate 1. Effect of *Sphagneticola calendulacea* leaf extract on cucumber seedling growth Plate

Plate 2. Effect of *Sphagneticola calendulacea* leaf extract on pumpkin seedling growth

Plate 3. Effect of *Sphagneticola calendulacea* leaf extract on mustard seedling growth Plate

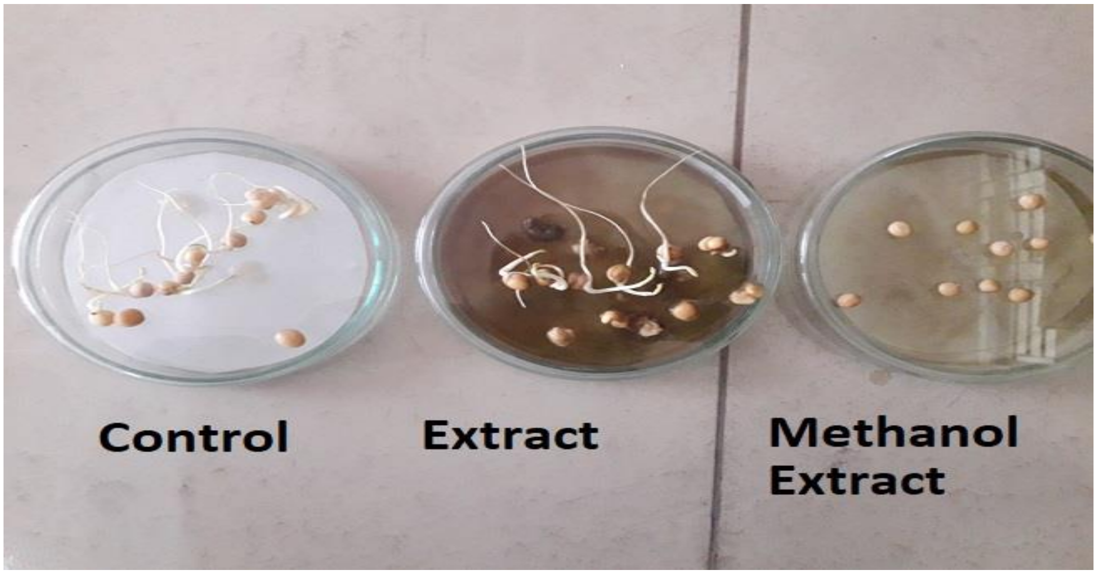


Plate 4. Effect of *Sphagneticola calendulacea* leaf extract on peas seedling growth Plate

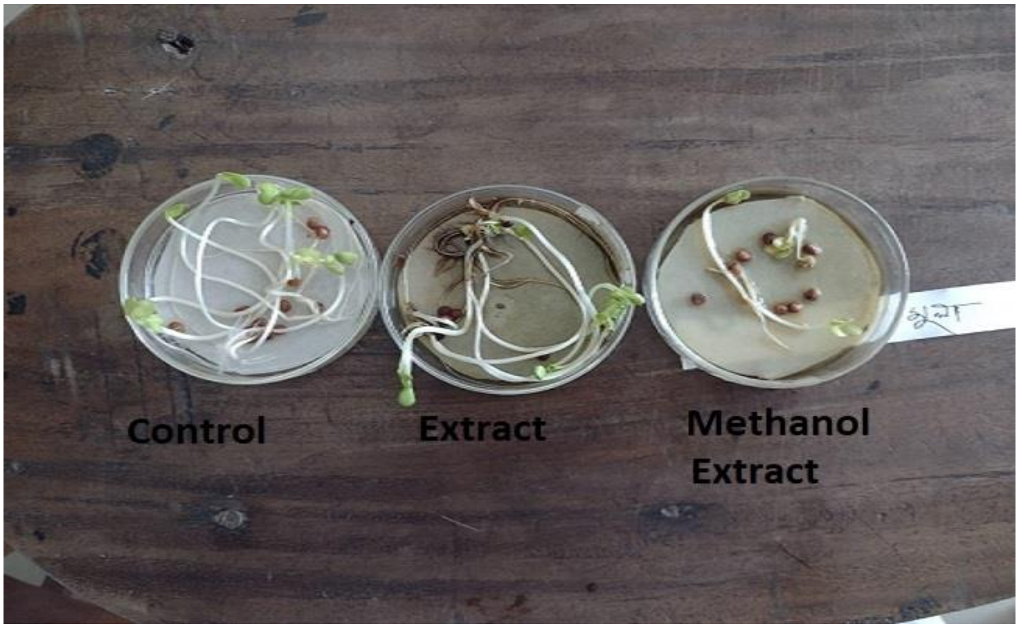


Plate 5. Effect of *Sphagneticola calendulacea* leaf extract on radish seedling growth Plate

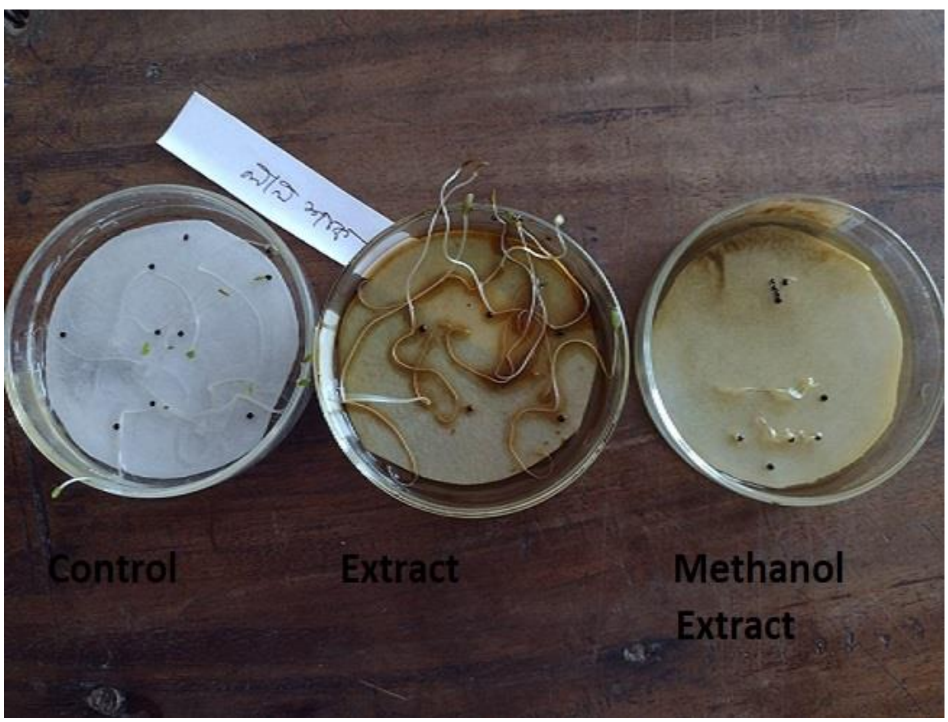


Plate 6. Effect of *Sphagneticola calendulacea* leaf extract on red amaranth seedling growth Plate

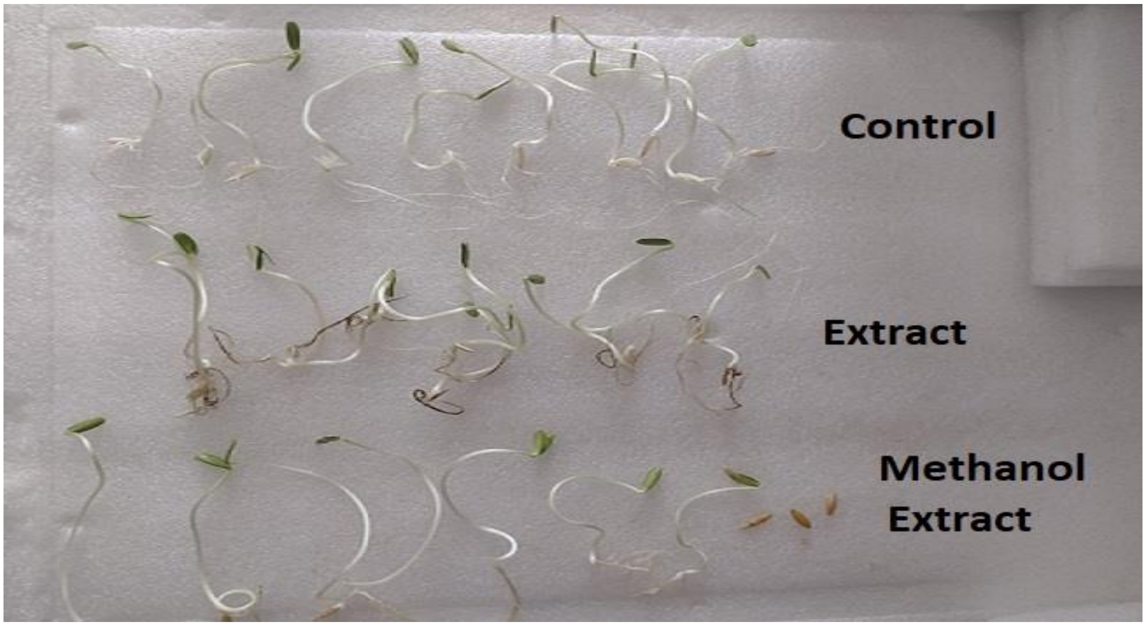


Plate 7. Growth of radicle and plumule on cucumber seedling

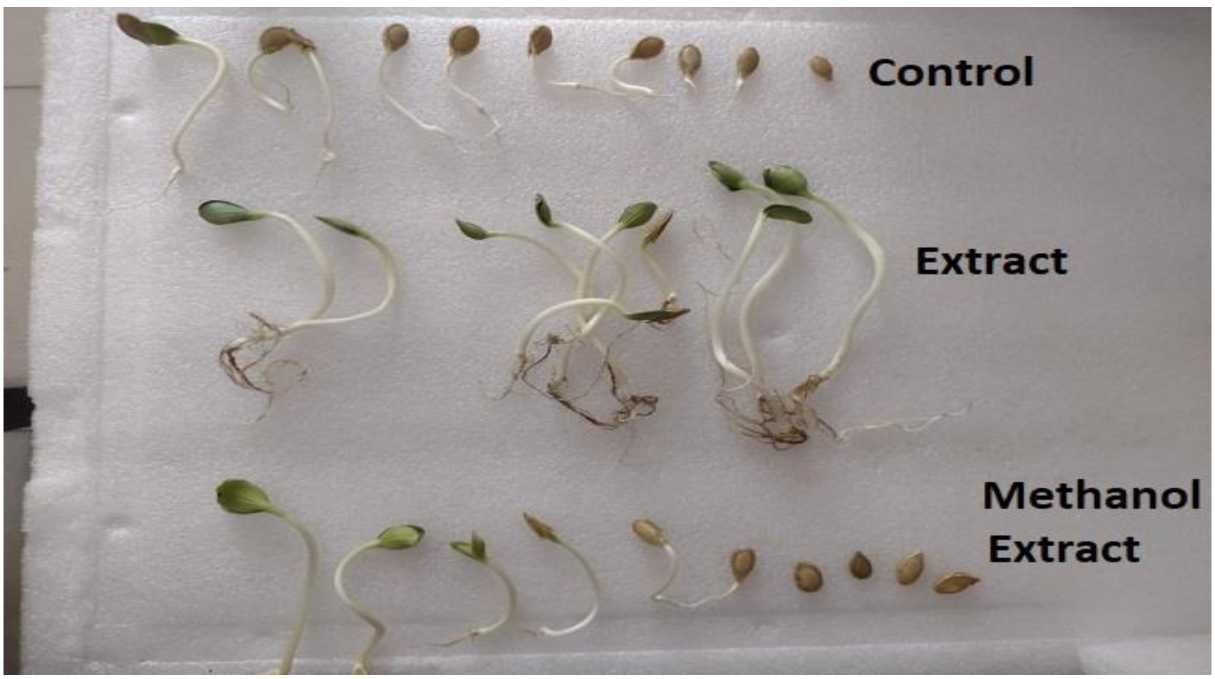


Plate 8. Growth of radicle and plumule on pumpkin seedling

Sprayers and Weedicides

Spraying in the experimental site