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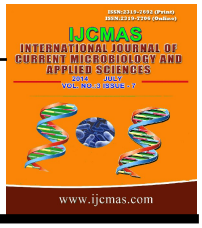

Original Research Article

Allelopathic effect of *Parthenium hysterophorus* L. on growth and productivity of *Zea mays* L. and its phytochemical screening.

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A B S T R A C T

Allelopathic effects of leaf and stem extract and dry biomass of *Parthenium hysterophorus* L. at different concentration on germination and seedling growth and its population density on productivity of corn (*Zea mays* L) were examined at Manipur University. At 10% (w/ v) of leaf and stem extract, cent percent and 91.6% inhibition of seed germination were observed respectively. Parthenium dry biomass incorporated in soil significantly reduced germination and seedling growth of maize with 50 g to 400 g per 10 kg of soil. The population of Parthenium also affects plant height, dry biomass and productivity of corn length, weight and grain weight per corn with increase in population ratio. The qualitative tests for phytochemical constituents of Parthenium revealed that in methanol extract all the tested Phytochemical (Alkaloids, Flavonoids, Phenols, Glycosides, Cardiac glycosides, Terpenoids, Saponins, Steroids and Tannins)were found to be present whereas in aqueous extract Glycosides, Cardiac glycosides, Terpenoids, Saponin and tannin were found to be absent . Parthenium in the form of extract or residue or growing weed can affect the germination, growth and productivity of *Zea mays.* So there is an urgent need of integrated Parthenium management strategy to stop further spread of this alien weed.

Introduction

Allelopathy concerns the effects of one plant on another due to chemical released by them or the breakdown of their metabolites. It is expected to be an important mechanism in the plant invasion process because the lack of co-evolved tolerance of resident vegetation to new chemical produced by the invader could allow these newly arrived species to dominant natural plant communities (Hierro and Callaway, 2003). Reduction in native plant biodiversity in natural and agro-ecosystems caused by alien invasive weeds are now being recognized as some of the world's major emerging problems. Such alarming threat are also being noticed in India. Parthenium is an annual herbaceous prolific weed belonging to Asteraceae family and has been accidentally introduced in India along with food grain PL-480. Parthenium weed not only competes with desirable crop and pasture species but also reported as a health

hazard to human being and livestock is a significant threat to the viability of natural agro-ecosystems throughout the world (Adkins and Navie,2006). *P .hysterophorus* is perhaps the most troublesome and noxious weed of urban and rural India (Kohli *et al*.2006). The invasive nature of this weed is evident from its ability to form huge monocultural strands with no other plant in the vicinity (Riaz,T and Javaid,A.,2009). Although a number of studies on the impacts of Parthenium weed on crops have been done in different part of India. Very little work has been done on Parthenium in Manipur so far. Even most of the people of Manipur do not aware about Parthenium problem although it is found to be grown gregariously along the road side, pasture land and around the cropped and non-cropped land. The objectives of this investigation were to determine the relative toxicity of parthenium aqueous extract and dry biomass on *Zea mays* germination and seedling growth and the effect of parthenium population on productivity of *Zea mays* in microplot field condition.

Materials and Methods

Manipur is one of the eight states of North Eastern India and the study site is located at latitude 24.8200° N and Longitude 93.9500° E at an elevation of 790 msl. It is a valley surrounded by hill in all directions. The study site had three main season in a year *viz*. Summer (April to May), Rainy (June to October) and Winter (November to March). Sporadic winter rains were common during November to January. The annual mean temperature was 27^0C – 30^0C, the mean maximum temperature of 32^0C in April – May and the mean minimum temperature of 6^0C in December – January.

Preparation of aqueous leaf and stem extract

Ten (10) gram of air dried leaves and stem of *Parthenium hysterophorus* was ground, mixed with 100 ml distilled water and left for 24 h in dark at the room temperature (average during day 25ºC) for extraction. Aqueous extract was obtained as filtrate of the mixture and final volume was adjusted to 100 ml, this gave 10% aqueous extract. The extract was considered as stock solution (1:10 w/v) and a series of solution with different strengths (2, 4, 6 and 8 and 10%) were prepared by dilution with distilled water.

Phytotoxicity of Parthenium extract to *Zea mays*

Before seed germination test, empty and undeveloped seeds were discarded by floating 5 min in tap water to remove dirt and dust. The seeds were surfaced sterilized with 0.1% mercuric chloride ($HgCl_2$) solution for 3 min and then washed 6-7 times with distilled water. Sixty seeds were divided into three replicates of 20 seeds each. These were soaked for 3 hours in 10 ml of 2%, 4%, 6%, 8% and 10% aqueous leaf and stem extracts of *Parthenium hysterophorus*. Control seeds were soaked in 10 ml distilled water. Twenty (20) seeds each were allowed to germinate in the moist petridish lining by filter paper with different concentrations of extracts and distilled water as control. The petridishes were covered and placed in sealed polythene bag and kept undisturbed for 10 days in a plant growth chamber. The experiments were carried out under 70% relative humidity at 25 ± 2^0C with a 12 h photoperiod to test the germination under different concentration of extracts in three replicate with completely randomized block design. The germination of seeds, plumule and radicle length of seedlings were recorded on the 10^{th} day and dry weight per plant was recorded after drying in an oven at $55\text{-}65^0$ C for 48 hr. The vigour index of Parthenium seedling was calculated following Abdul-Baki and Anderson (1973).

Allelopathic effect of Parthenium dry biomass on *Zea mays* Growth

Mature Parthenium whole plants were chopped into small section of 1-2 cm and air dried for one week. Dried Parthenium biomass was weighed out separately in the quantity of 50, 100, 150,200,300 and 400 g. The above quantity was mixed thoroughly with 10kg soil separately and sufficient quantity of water was added to all the plastic bags and kept for one week in the glass house to develop any possible microbial activity. The sufficient quantity of the healthy seeds of *Zea mays* were sterilized with 3 percent sodium hypochlorite solution and then thoroughly washed with water several times. 20 healthy seeds of *Zea mays* were sown in each plastic bag at 0.5 cm (field sowing density) below the soil surface to all the treated (50, 100, 150,200 and 300 g.) and control plastic bags. Each treatment was replicated three times and kept in randomized complete design.

The numbers of seeds germination were counted daily till completion of germination. Percentage of germination and speed of germination index "S" were calculated following Khandakar and Brad bear (1983).
as S=[N1/1+N2/2+N3/3…….Nn/n] ×100/1
where N1, N2, N3……Nn, proportion of seeds which germinated on day 1, 2, 3 ...n following set up of the experiment.

To assess the growth of *Zea mays* plant, after 15 days seven healthy plants from each plastic bag were harvested and shoot length, root length and dry weight were measured .The plants were thinned and only seven(7) healthy plants were kept in each bag. After one month, the plants were again harvested and shoot length, root length and dry weight were measured.

Effect on Productivity of *Zea mays*

The experiment was conducted in field of Life Science Department, Manipur University from April to August, 2013. Seed of *Parthenium* and *Zea mays* were sown in 2x2 m^2 microplots in randomized complete block design. The nursery of parthenium and *Zea mays* was prepared on raised seed beds. After one month of sowing, the required population of *Zea mays* and parthenium in different ratios of 1:5, 1:10, 1:15 and 1:20 was maintained in the field. Plot of *Zea mays* alone was maintained as control. Observation on plant height, fresh weight, dry weight and productivity on corn were done after 4 months of sowing in treated and control.

Phytochemical analysis

The powdered Parthenium leaf material (200 gm) was sequentially extracted with 2500 ml methanol separately by using Soxhlet apparatus. The process of extraction continues till the solvent in the siphon tube of an extractor become colorless. After that the extract was taken in a beaker and kept on hot plate and heated at 30-40°C till all the solvent got evaporated. The preliminary phytochemical analysis of methanol and aqueous extract of Parthenium was carried out using standard procedures (Trease, G.E, Evans, 1989; Sofoware, A., 1993 and Harborne, J.B., 1973) to identify the phytochemical constituents (Alkaloids, Flavonoids, Phenols, Glycosides, Cardiac glycosides, Terpenoids, Saponins, Steroids and Tannins)

Statistics Analysis: Data were subjected to the analysis of variance and means were compared using Least Significant Difference Test at $p \geq 0.05$

Results and Discussion

Effect of aqueous extract on germination and seedling growth

Both leaf and stem aqueous extract of Parthenium exhibited significant inhibition in seed germination of *Zea mays* (Table 1). The result obtained were concentration dependent as increasing leaf and stem extract concentration significantly inhibited germination of *Zea mays*. The cent percent inhibition of *Zea mays* germination and 91.6% inhibition were observed in 10% of aqueous leaf and stem extract respectively as compared to control. Plumule length was consistently reduced with increasing concentration of Parthenium aqueous leaf and stem extract with maximum suppression of plumule length recorded in higher concentration of parthenium leaf extract (8%) as compared to control. At higher concentration the plumule length was reduced to 75.3% in leaf extract (8%) and 91.7% in stem extract (10%). The radicle length of *Zea mays* was reduced by 26.7 - 75.3% in 2 -8% aqueous leaf extract and 14.8-78.1% in 2-10% stem extract over control.

Results presented in Table 2 indicate that both leaf and stem aqueous extract of *P. hysterophorus* significantly ($p \geq 0.05$) reduce dry and fresh weight of the *Zea mays*. The highest values of fresh weight were 0.617 g and 0.631 g for leaf and stem aqueous extract respectively compared with the control while dry weight values were 0.37g and 0.428 g for leaf and stem extract respectively at 2% concentration. The lowest value of 0.29 g and 0.21 g fresh weight for leaf and stem extract was observed at 8% and 10% while dry weight values were 0.168 and 0.14 respectively .These results suggest that the fresh weight and dry weight of maize decreases significantly ($p \geq 0.05$) as concentration levels were increased. The dry biomass was reduced to 66.2% and 83.2% in leaf extract (8%) and stem extract (10%) respectively.

Tefera (2002) also reported that 10% leaf aqueous extract of *Parthenium hysterophorus* resulted in complete failure of seed germination in *Eragostis tef*. Earlier works have reported that among the treatment 8% and 10% aqueous extracts had the strongest inhibitory effect on germination of *Zea mays* L.(Seerjana *et al*,2007). Leaf aqueous extract(10%) completely inhibited seed germination of *Zea mays*. It may be due to some alleochemicals present in the leaf extract which prevented growth of embryo or caused the death. The extract of *Parthenium hysterophorus* induced a variety of chromosomal aberrations in dividing cells, which increased significantly with increasing concentration and duration of exposure (Rajendiran ,2005).

Plumule length was consistently reduced with increasing concentration of Parthenium aqueous leaf and stem extract. Result are similar to the finding of Maharjan *et al*., (2007) who concluded that increasing concentration of Parthenium water extract exhibited inhibitory impacts on seedling growth and seed germination of cereal crops. Earlier works reported that Parthenium has deadly allelopathic effects on rice, wheat, chickpea, soyabean and mustard (Karim and Forzwa,2010; Biswas,2010; Hridya and Rajendiran,2013). There was a gradual decrease in seed germination and different growth parameter with the increase in concentration of Parthenium leaf and stem extracts. These results showed that leaf aqueous extract of Parthenium exhibited significant inhibitory effect on seed germination and seedling growth had adverse effect than the stem

extract. Tefera (2002) also found that the inhibitory allelopathic impact of leaf extract was more powerful than the other vegetative parts. Thus the inhibitory effect of *P. hysterophorus* on seed germination and seedling growth of *Zea mays* may be due to presence of growth inhibitors in the extract.

Residue effect on germination and seedling growth of *Zea mays*

Effect of Parthenium dry biomass on percent of germination, speed of germination, fresh and dry weights of Parthenium seedling of Maize are shown in Table 3. The dried biomass of *P. hysterophorus* in soil markedly reduced the germination percentage and speed of germination index of Z*ea mays* with increase of amount as compared to control. The dry biomass of Parthenium reduced germination percentage of maize by 24.3% to 55.03% with 50g to 400g of treatment as compared to control. It was observed that the speed of germination index was keep on decreasing as the concentration of the biomass is increasing. It was found to be extremely low(2.96) as compared to control in 400g/10 kg soil. This showed that weed dry biomass in the soil contain some inhibiting chemicals resulting in the reduced germination of maize. This may be presumably due to the release of phytotoxins from the decaying material that remains active and stable for considerable duration in soil. In higher concentration (200, 300 and 400g/10 kg soil each) the shoot length was reduced by 53.4 – 71.2%, 41.7- 64.5% and root length by 47.6% - 71.4%, 58.5%- 75.6% as compared to control after 15 and 30 DAS respectively. Jabeen, N and Ahmed, M (2009) found that the dry powder of *Asphodelus tenuifolius, Euphorbia hirta* and *Fumaria indica* also exhibit negative allelopathic impact on seed germination and speed of germination index of Maize. It has been reported that incorporation of Parthenium residue significantly reduced shoot growth of different species of *Brassica* (Singh *et al,* 2005). Both fresh and dry weights of seedling were significantly decreases after 15 and 30 DAS as compared to control in 300 and 400g incorporated soil. The presence of phenollics in Parthenium residues and their interference with soil chemistry upon release may be responsible for decrease in the growth of *Zea mays*. It may be concluded that Parthenium dry biomass considerably depressed germination percentage and speed of germination index of maize, while fresh and dry weight of maize were affected only at higher concentration of dry biomass used in soil.

Effect on productivity of Corn

The population of Parthenium also affects plant height, dry biomass and the productivity of corn length, weight and grain weight per corn with increase in population ratio. There was a detectable impact on the growth and dry biomass of *Zea mays* by Parthenium (Table 4.). It was observed that at high ratio (20:1) population of parthenium the height and dry biomass of *Zea mays* was reduced to 21.1% and 42.3% respectively as compared to control. The corn weight and length were reduced to 50.9% and 51.2% in 20:1 population ratio respectively. The grain weight per corn was deadly affected in 15:1 and 20:1 ratio and reduced to 41.4 % and 52.7% respectively as compared to control. This may presumably be due to the release of inhibitory compounds that remain active and stable for considerable duration in soil which causes marked reduction or stop growth of plant (Shaukat & Siddiqui, 2001).

Table.1 Effect of aqueous leaf and stem extract of *Parthenium hysterophorus* on the germination and seedling length of *Zea mays*

Treatment	Leaf extract of Parthenium			Stem extract of Parthenium		
	Germination %	Radicle Length (cm)	Plumule Length (cm)	Germination %	Radicle Length (cm)	Plumule Length (cm)
2%	53.3	10.82	3.52	62.1	11.68	4.1
4%	38.3	6.34	2.54	50	7.54	2.98
6%	26.7	4.76	1.76	38.3	5.52	2.14
8%	22.4	3.74	1.04	31.6	4.64	1.52
10%	NG	0	0	8.3	2.44	1.08
Control	93.3	14.84	5.52	98.3	14.88	5.22
SEM		0.17	0.14		0.173	0.14
LSD at p≥0.05		0.34	0.26		0.36	0.29

NG= no germination

Table.2 Effect of aqueous leaf and stem extract of *Parthenium hysterophorus* on fresh weight, dry weight and vigour index of *Zea mays* plant. Value are means of three replicate.

Treatment	Leaf extract of Parthenium			Stem extract of Parthenium		
	Fresh Weight (gm)	Dry biomass Weight (gm)	Vigour Index	Fresh Weight(gm)	Dry biomass Weight (gm)	Vigour index
2%	0.617	0.37	7643.2	0.523	0.428	9799.4
4%	0.528	0.282	3401.04	0.461	0.35	5240
6%	0.314	0.246	1740.8	0.342	0.29	2933.8
8%	0.297	0.168	1070.7	0.210	0.202	1946.6
10%	0	0	0	0.132	0.14	292.2
Control	0.875	0.558	18995.8	0.631	0.64	19758.3
SEM	0.02	0.02		0.017	0.02	
LSD at p≥0.05	0.04	0.03		0.034	0.03	

Table.3 Effect of different concentration of Parthenium dry biomass on growth of maize *(Zea mays)* plants

Treatment	Germination % after 5 days	Speed of germination index	Shoot length (cm)		Root length (cm)		Dry weight (g)		Vigour index	
			15 days	30 days	15 days	30 days	15 days	30 days	15 days	30 days
50g/10kg soil	74.4	7.2	5.72	17	4.58	12.86	2.20	4.67	7663.2	22215.8
100g/10kg soil	68.3	5.05	4.56	16.18	3.68	11.36	1.87	4.21	5627.9	18809.0
150g/10kg soil	55.3	4.22	4.32	14.38	3.28	9.62	1.67	3.63	4202.8	13272
200g/10kg soil	50	3.67	3.48	11	2.74	7.32	1.37	3.29	3110	9160
300g/10kg soil	49.3	3.21	2.42	8.62	2.02	6.22	1.17	2.97	2188.9	7316.1
400g/10kg soil	44.2	2.92	2.2	6.46	1.48	4.86	0.94	2.67	1626.6	5003.4
Control	98.3	8.71	7.58	18.34	6.38	15.34	2.52	5.3	13722.7	33197.4
SEM			0.13	0.14	0.12	0.17	0.064	0.04		
LSD at p≥0.05			0.27	0.29	0.24	0.35	0.13	0.07		

Table.4 Effect of Parthenium population on the growth and productivity of *Zea mays*

Treatment P:Z	Plant height (cm)	Whole plant fresh weight (g)	Dry Plant biomass/ plant	Weight of corn (g)	Corn length (cm)	Grain weight/corn (g)
Control	251.6	537.2	152.2	150.46	14.3	93.8
5:1	227.4	495	127.2	132.08	11.66	84.8
10:1	219.2	480	123.8	105.76	10.48	69.6
15:1	211.4	465.3	110.4	92.52	9.54	55
20:1	198.4	410.6	87.8	73.76	6.98	44.4
SEM	2.25	4.20	3.41	1.95	0.27	2.72
LSD at p≥0.05	4.64	8.64	7.03	4.01	0.56	5.60

P= Parthenium. Z=*Zea mays*

Table.5 Phytochemical screening of methanol and aqueous extract of *Parthenium hysterophorus*

Sl. No.	Phytochemicals	*Methanol extract*	*Aqueous extract*
1	Alkaloids	+	+
2	Flavonoids	+	+
3	Phenols	+	+
4	Glycosides	+	-
5	Cardiac glycosides	+	-
6	Terpenoids	+	-
7	Saponins	+	-
8	Steroids	+	+
9	Tannins	+	-

+ = Presence of the compound; - = Absence of the compound

It has been reported that Parthenium exhibit allelopathic effects thus inhibits the germination and growth of neighboring plants by releasing various allelochemicals such as water soluble phenolic and sesquiterpene lactones including parthenin and coronopolin (Jarvis *et al*.,1985; Riaz. T and Javaid. A, 2009). In a previous study in Ethiopia, Parthenium significantly suppressed the growth and yield of sorghum crop. Yield of grain sorghum was reduced by 69% when the parthenium density was only three plants per square meter ; reductions as high as 97% occurred at higher weed densities (Tamado *et al.*, 2002). The present trial also showed the effect on maize corn weight and grain weight with increase in parthenium ratio.The present trial also showed the same effect.

Phytochemical screening

The methanol and aqueous extract of *Parthenium hysterophorus* L. leaves were subjected to various qualitative tests for phytochemical constituents which revealed the presence of diverse constituents are shown in Table 5. The result revealed that in methanol extract all the tested Phytochemical were found to be present whereas in aqueous extract Glycosides, Cardiac glycosides, Terpenoids, Saponin and tannin were found to be absent. The phenolic compound are the one of the largest and most ubiquitous groups of plant metabolites. Earlier workers reported that Parthenium has a negative and positive allelopathic effects on many agricultural crops and other plant species (Oudhia *et al*.,1997). The allelochemicals responsible for affecting many plant species are sesquiterpene lactone and phenolics(Swaminathan *et al.,* 1990). The allelopathic effects of Parthenium on other plants is largely arttributed to the presence of Parthenin which is found in various parts of the weed(Batish *et al.,* 2002) which can be leach out from this plant parts when alive or dead. It has been reported that Parthenium also released phenolic acid from its roots and leaves(Villiappan and Tower. 1988) as well as from its achenes(Picman and Picman, 1984) and from decaying plant residue in the soil(Kanchan and Jayachandra, 1980; Mersie and Singh, 1988).

References

Adkins, S.W. and Navie, S.C. (2006). Parthenium weed: a potential major weed for agro ecosystems in Pakistan. *Pakistan Journal of Weed Science Research* 12:19-3.

Batish,D.R, Singh ,H.P, Kohli,R.K, Saxena, D.B, Kaur ,S. (2002).Allelopathic effecys of Parthenin against two weedy species, *Avena fatua* and *Bidens pilosa*. *Environ. Exp. Bot*, 47:149-155.

Biswas, O.(2010). Allelopathic effects of plant debris of parthenium weed on seed germination, growth and development of field crops. M.S Thesis, submitted to the department of Agronomy, BAU, Mymensingh.

Hierro, J.L. and Callaway, R.M.(2003).Allelopathy and exotic plant invasion. *Plant and Soil* 256:29-39.

Jabeen, N.and Ahmed, M .(2009). Possible allelopathi effects of three different weeds on germination and growth of Maize (*Zea mays*) Cultivars. *Pak.J.Bot*., 41(4):1677-1683.

Jarvis, B.B., Pena, N.B., Rao, M.M., and Mandava, N.B.(1985). Allelopathic agents from *Parthenium hysterophorus* and *Baccharis megapotamica*. *The chemistry of allelopathy*. Wangshington DC, USA; American Chemical Society, pp. 149-159.

Karim, S.M.R. and Forzwa, R. (2010).Allelopathic effects of parthenium weed on the seed germination and seedling growth of field crops. Abstract, Annual Botanical Conference held at Chittagong University ,Bangladesh during 9 to 10 January ,2010,pp.38-39.

Kanchan, S.D, Jayachandra.(1980). Allelopathic effects od *Parthenium hysterophorus* L. Part IV. Identification of inhibitors. *Plant Soil*.55: 67-75.

Kohli, R.K., Batish, D.R., Singh, H. and Dogra ,K.S.(2006). Status, invasiveness and environmental threats of three tropical America invasive weeds(*Parthenium hysterophorus* L.,Ageratum conyzoides L.,Lantana camara L.) in India .*Biological Invasions* 8(7):1501-1510.

Maharjan,S., Shrestha,B.B., Jha ,P.K.(2007). Allelopathic effect of aqueous extract of leaves of *Parthenium hysterophorus* L.on seed germination and seedling growth of some cultivated and wild herbaceous species. *Sc.World*.5(5):33-39.

Mohanan, H. and Rajendiran K.(2013).Allelopathy and cytotoxicity of aqueous extracts of *Parthenium hysterophorus* L. on *Oryza sativa* L.Var.Asd-16.*International Journal of Food , Agriculture and Veterinary Sciences*.3(3). Pp.55-61.

Mersie, W., Singh M. (1988). Effect of phenolic acid and ragweed partheniun (Parthenium hysterophorus) extract on tomato (Lycopersicon esculentum) growth and nutrients and chlorophyll content. Weed Sciences 36:278-281

Oudhia, P., Kolhe ,S.S., Tripathi, R.S.(1997). Allelopathic effect of white top(*Parthenium hysterophorus* L.) On chickpea, Legume Res. 20(2):117-120.

Rajendiran, K. (2005). Mitodepressive effects of aqueous extracts of Parthenium hysterophorus L. on Vigna radiate (L) Wilczek. *Geobios* 32(4):237-240.

Riaz,T. and Javaid,A.(2009).Invasion of

hostile alien weed *Parthenium hysterophorus* L. in Wah Cantt, Pakistan. *The Journal of Animal and Plant Sciences* 19(1): 26-29

Saukat, S.S. and Siddiqui, I.A.(2001) Lantana camara in the soil changes the fungal community structure and reduces impact of *Meloidigyne javanica* on Mungbean . *Phytopathol.Medit*., 40:245-252.

Singh, S.P., Batish, D.R., Pandher, J.K. and Kohli, R.K.(2005) .Phytotoxic effects of *Parthenium hysterophorus* residue on three *Brassica* species. *Wees Biol. Manage* 5:105-109.

Sofowara , A.(1993). Medicinal plants and Traditional medicine in Africa. Spectrum Books Ltd, Ibadan, Nigeria .p.289.

Swaminathan,C., Vinaya Rai, R.S., Suresh ,K.K.(1990). Allelopathic effect of *Parthenium hysterophorus* on germination and seedling growth of a few multipurpose trees and arable crops. *J .Intl .Tree Crops*. 6:143-150.

Tamado, T., Ohlander, L. and Milberg,P. (2002). Interference by the weed *Parthenium hysterophorus* L. with grain sorghum: Influence of weed density and duration of competition. *International Journal of Pest management* 48:183-188.

Tefera ,T.(2002). Allelopathic effects of *Parthenium hysterophorus* extracts on seed germination and seedling growth of *Eragrostis* tef. *J.Agron.Crop Sci* 188:306-310.

Trease, G.E., Evans, W.C . (1989). Phamacognsy. 11th edn. Brailliar Tiridel Can. Macmillian publishers.