GLOBAL JOURNAL OF BIOLOGY, AGRICULTURE & HEALTH SCIENCES
(**Published By**: Global Institute for Research & Education)
www.gifre.org

ALLELOPATHIC EFFICACY OF *ZINGIBER OFFICINALE ROSC* AQUEOUS LEAF, STEM AND RHIZOME EXTRACT ON EARLY SEEDLING GROWTH OF *ZEA MAYS* L.

N. H. Bharath, N. K. Hemanth kumar* & Shobha Jagannath
Department of Studies in Botany, Manasagangotri, University of Mysore, Mysore, 570006, Karnataka, India
Corresponding author*

Abstract
In the present investigation an attempt was been made to assess the Allelopathic effect of Ginger (*Zingiber officinale*) on early seed growth parameters of Maize (*Zea mays*).The aqueous leaf, stem and rhizome extract of ginger showed inhibitory effects on seed germination, root length, shoot length, vigour index, percent totoxicity, fresh weight, dry weight, in maize seedlings. All these parameters were found to be decreased with increasing the aqueous leaf, stem and rhizome extract of ginger. In all parameters maximum value were recorded at control and the minimum value were recorded at 100% concentration. The findings of present study showed that inhibitory effect of ginger aqueous leaf, stem and rhizome extract may be due to the presence of allelochemicals *viz*. terpinoids, phenols and steroids.
Key words: Ginger, allelopathy, toxicity, germination.

INTRODUCTION
Allelopathy is a mechanism in which chemicals produced by some plant species may increase or decrease the associated plant growth (Jabeen and Ahmed, 2009). The earliest writing on allelopathy are attributed to Theophrastus (300 B.C), who noticed that harmful effect of Cabbage on a Vine and suggested that such effects were caused by "Odours" from cabbage plant (Willis., 1985). A more appropriate definition for allelopathy includes "The positive and negative effects of chemical compounds produced mainly from the secondary metabolism of plants, micro-organisms and fungi that have an influence upon the growth and development of agricultural and biological ecosystems (Kruse *et al.,* 2001). Such positive or negative effects are due to release of active biomolecules commonly called as "Allelochemicals" (Albuquerque *et al.,* 2010). The new synthetic chemicals with new target sites are decreasing. Natural compounds pose a great field for discovery of new environment friendly herbicides, so called "Bioherbicides" which based on compounds produced by living organisms. Among these bioherbicides allelochemical are significantly more in number. Plant allelochemicals can be successfully used in integrated weed management. However, not all systems of its application under field conditions are suitable and profitable enough (Soltys *et al*., 2013).

Ginger (*Zingiber officinale Rosc*.) is an important horticultural crop in south east Asia. It is an herbaceous perennial, grown as an annual crop for its spicy underground rhizome. China is the largest producer of Ginger. Ginger grows well in Pacific island nations like Fiji, Jamaica, India, Nepal and Korea. Indonesia, Nepal, Sri Lanka, Nigeria, Brazil and Thailand also cultivate ginger. In India Karnataka, Kerala, Tamilnadu, Gujarat, Tripura, Himachal Pradesh, Orissa, Sikkim, Madhya Pradesh, Rajasthan grows Ginger. Ginger is used throughout the world as a spice or fresh herb in cooking, flavouring candies, beverages, baked goods, sauces etc. It also has a traditional medicinal importance, used in treatment of nausea, motion, sickness, migraine and dyspepsia (Valenzuela, 2008). The Ginger plant shows Autotoxicity, which is nothing but intraspecific allelopathy, where a plant species inhibits the growth of its own kind through release of toxic chemicals into environment (Singh *et al*., 1999).

Maize (*Zea mays L.*) or Corn belongs to the family Poaceae. It is second most important cereal crop, cultivated worldwide. The word Zea is derive from Greek word means food grass. USA is the largest producer of maize. Maize occupies an important place in Indian agriculture. It is the third most cultivated cereal in India after wheat and rice. The major growing states are Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Punjab, Andhra Pradesh, Himachal Pradesh, West Bengal, Karnataka, Jammu and Kashmir. These states together produce for over 95% of maize in India. The estimate of maize production in 2007 was 13-14 million tonnes from an area of 7.2 million hectare with an average productivity of 2tonnes/hectare. Maize is a basic element of animal feed & raw material for manufacture of many industrial products, such as corn starch, Malto dextrins, corn oil, corn syrup, products of fermentation and distillation industries. It is also being recently used as bio fuel (Anonymous, 2010).

The present study was undertaken to study the allelopathic effect of ginger leaves, stem and rhizome aqueous extracts of different concentrations to determine inhibitory or stimulatory effects on seed germination and seedling growth of Maize.

Materials and Methods
Collection of seed samples and plant materials
Three cultivar varieties of maize- NAC-6004, NAC-6002 and NAH-6004 were collected from Maize breeding station, V.C form, Mandya. Ginger plants were collected from growing fields of Channapura village. In order to select best variety, NAC-6004, NAC-6002 and NAH-6004 varieties were subjected to preliminary germination studies. Among the three varieties NAC 6004 showed maximum percentage of germination, it showed maximum resistance to fungal infection and suitable for laboratory experimental condition. Hence NAC 6004 maize variety was selected for further studies.

***Preparation of Ginger aqueous extracts*:**

Plants were washed properly with pure water then plants were separated into leaves, stem and rhizome, shade dried for 30 days. The dried leaves and stems were chopped into 1cm long pieces and rhizomes were chopped into 0.5cm thick slices. The components were then oven dried at 60^0 C for 2days. 100g of dried rhizomes, leaves and stems were soaked in 1lt deionised water at 25^0 C for 24hrs in a shaker to get a concentration of 100g dry tissue/litre. The extracts were taken out after 24hrs and respectively filtered through filter paper to remove the fibre debris and centrifuged at 3000rpm for 4hour. The supernatant was filtered again. Fresh stock extract were kept in a refrigerator at 3^0C until used.

***Germination studies*:**

Stock extracts (rhizome, stem, leaf) were diluted with sterile distilled water to get different concentrations of 20%, 40%, 60%, 80% and 100%. Seed germination tests were conducted for each extracts as follows: As per the ISTA (1985) standard, Root length, Shoot length and Vigour index determined following method of Abdul Baki and Anderson (1973), Percentage of phytotoxicity (Chion and Muller, 1972). The fresh weight and dry weight of seedlings was determined following the method (Agarwal, 1994). Tolerance index (Turner and Marshal, 1972).

Results and Discussion

The seeds of NAC 6004 maize variety were treated with different concentration of aqueous extracts of stem, leaf and rhizome of ginger to study the effect on germination Table-1, 2 and 3) respectively. The Percentage of germination was found to be decreased with increased concentration of all three aqueous extracts with respect to control. An analysis of variance indicates that there was a significant difference in the germination percentage of maize seedlings between control and all other concentrations of different parts of the ginger extract. The maximum percentage of germination was recorded in control (89.66%) compared to that of all the concentrations. The maximum percentage of germination in ginger stem, leaf and rhizome extract recorded in 20% concentration (79.66%, 79.66% and 74.66% respectively). Whereas the minimum percentage of germination in ginger stem, leaf and rhizome extract was found to be at 100% concentration (31.66%, 30.25% and 28.66% respectively). Evolution of weeds resistance to herbicides demands new solutions to cope with the problem since economic losses generated by weeds can be higher than those caused by other pests. It is necessary to implement new class of natural herbicides with was new mechanism of action and targets which never exploited before. (soltys *et al.*, 2013).

Effect of different concentration of ginger stem, leaf and rhizome aqueous extracts on vigour index of maize showed significance decrease when compared with control (Table-1, 2 and 3 respectively). As concentration of aqueous extracts increased the vigour index significantly decreased. Maximum vigour index recorded in control sets (2330.95) and minimum value recorded in 100% concentrated aqueous extract of rhizome (293.66). Rhizome extract more effectively decreased the vigour than stem and leaf extracts. Leaf and stem aqueous extracts showed more or less similar effect on vigour of seedlings. In ginger stem, leaf and rhizome extract with respect to vigour index the maximum value was recorded in 20% concentration (1699.83, 1500.50 and 1485.10 respectively) and minimum value was recorded in 100% concentration (407.13, 418.99 and 296.66 respectively). The allelochemicals inhibit the growth of the radicle and plumule in various crops by blocking hydrolysis of nutrients and cell division (Oyerinde *et al.,* 2009). Previous studies conducted in China revealed that the aqueous extract of ginger stem, leaf and rhizome inhibit the growth of soybean and chive seedlings. The results showed that aqueous extracts from different parts of ginger had a phytotoxic influence on maize. The effect of extracts on seedling germination, vigour index, tolerance index and pytotoxicity was largely dependent on the concentration of aqueous extracts. Stem, leaf and rhizome extracts of ginger caused maximum inhibition on germination of chive and soybean at higher concentration except one case, where rhizome extract of ginger at maximum concentration (100%) didn't inhibit germination in soybean (Han *et al*., 2008). Water soluble leachate of fresh leaves of *A.lebbeck* reduces the germination as well as suppresses the growth and development of agricultural crops. The present investigation revealed that stem, leaf and rhizome extracts of ginger inhibits germination in maize but degree of inhibition was changes with change in concentration. Stem and leaf extracts are mostly similar in action, but rhizome extract shows significantly high inhibition on germination of maize (Han *et al.*, 2008) concluded that among stem, leaf and rhizome extracts of ginger, stem extract is more effectively inhibited the germination of soybean and chive and rhizome extract was least effective on germination.

Different concentrations of ginger stem, leaf and rhizome extracts effects on tolerance index is represented in Table-1, 2 and 3 respectively. The value with respect to tolerance index was significantly decreased with increase in the concentration of aqueous extracts. Maximum tolerance index was recorded in control (100.00). Among three aqueous extracts, rhizome aqueous extract of ginger showed high percentage of inhibition in 100%concentrated extract (33.30) which is the minimum value with respect to tolerance index. In stem, leaf and rhizome extract of ginger the maximum value was recorded in 20% concentration (93.10, 79.30 and 71.45 respectively) and minimum value was recorded in 100% concentration (61.39, 45.82 and 33.30 respectively).

The values with respect to phytotoxicity in maize seedlings at different concentration of aqueous extracts of ginger stem, leaf and rhizome were found to be significantly different (Represented in Table-1, 2 and 3 respectively). In control phytotoxicity value was 0.00. Phytotoxicity increased with increase in concentration of aqueous extracts. At 100% concentration of stem, leaf and rhizome extracts the phytotoxicity was highest. Rhizome aqueous extract showed more phytotoxic effect than stem and leaf extracts. In stem, leaf and rhizome extract the phytoxicity value was higher in 100% concentration (30.46, 29.32 and 51.48 respectively) and minimum value was recorded in 20% concentration (3.94, 3.25 and 15.86 respectively). Phytotoxic effect of stem extract of ginger is more on soybean and chive and rhizome extract is least effective (Han *et al.*, 2008). In our investigation rhizome extract showed more phytotoxic effect than stem and leaf extracts on maize seedlings and stem and leaf extracts show same amount of phytotoxicity on maize. The present study revealed that extracts of ginger stem, leaf and rhizome significantly reduced the vigour index in maize when compared to control and rhizome extract more effectively reduces the vigour index than stem and leaf extracts. Our results are in line

of earlier were recorded by Tanveer *et al*., 2010 with using extract of *Euphorbia heliscopia* against wheat, chick pea and lentil where vigour index decreased with increase in concentration extract. Melkania, (1984) found that *Jatropa curcus* stimulate the growth of maize. Ginger extracts suppress the growth of maize in all ways.

Effect of aqueous extracts of ginger stem, leaf and rhizome on root and shoot length of maize seedlings were represented in the table-1, 2 and 3. The maximum root length was observed in control (11.18 cm). In stem, leaf and rhizome extract of ginger the maximum root length was recorded in 20% concentration (9.36cm, 9.93cm and 8.54cm respectively) and minimum root length was recorded in 100% concentration (6.54cm, 5.32 and 4.87cm respectively). Compared to control (16.23cm) the shoot length decreased in aqueous extracts with increase in concentration of extract. The maximum shoot length in stem, leaf and rhizome extract of ginger was recorded in 20% concentration (11.96cm, 11.10cm and 11.39cm respectively) and minimum shoot length was observed in 100% concentration (6.10cm, 5.67cm and 5.35cm respectively). In present study both root and shoot lengths are significantly decreased when treated with different concentration of ginger stem, leaf and rhizome extracts. The root length was decreased with increase in concentration of extracts. Shoot length is also decreased with increased concentration of extracts when compared with control. The results were corroborated with the findings of Turk and Tawaha, 2003 who reported that leaf extract of black mustard exhibited the greatest inhibition on oat shoot and root growth. The similar results were obtained to Han *et al*., in 2008. Aqueous extracts of different parts of ginger inhibits the hypocotyls length of chive compared to control, the highest concentration ($80g\ l^{-1}$) of stem extract resulted in no hypocotyl development. Adverse effect of stem extract on radicle growth in chive was similar to that of hypocotyls. At lower concentrations of rhizome and leaf extracts there is no such adverse effect was occurred.

Effect of ginger stem, leaf and rhizome aqueous extracts on fresh weight and dry weight of maize seedlings presented in the table 1, 2 and 3 respectively. In aqueous extracts, fresh weight was decreased with increase in concentration. In stem, leaf and rhizome extract of ginger the maximum fresh weight was recorded in 20% concentration (0.71g, 0.74g and 2.60g respectively) and minimum fresh weight was recorded in 100% concentration (0.37g, 0.42g and 0.38g respectively). The dry weight was found to be increased with increase in concentration of ginger aqueous extracts. In stem, leaf and rhizome extract the maximum dry weigh observed in 100% concentration (0.34g, 0.41g and 0.34g respectively) and minimum dry weight was recorded in 20% concentration (0.23g, 0.23g and 0.20g respectively). In the present investigation the fresh weight was highly affected as the concentration of extract increased. It decreased with increase in concentration and dry weight increased slightly with increase in concentration of aqueous extracts of ginger. Jabeen and Ahmed, (2009) reported that shoot extract of *Fumaria indica* enhanced the growth of maize and the fresh weight of seedling increased with increase in concentration and dry weight decreased with increase in concentration because of the presence of growth enhancing chemicals in the extract. They also reported that powder of *Asphodelus tenifolius* reduced the fresh weight of maize at high concentration. In present study the fresh weight decreased with increase in concentration which may be because of the presence of growth inhibiting allelochemicals in the ginger extract. Raoof and Siddiqui, (2012) reported that extract of *T.cordifolia* significantly decreases the dry weight of green gram in all concentrations. Chon *et al*., 2000 reported that phenolic compounds evaluated from alfalfa exhibited various degree of inhibition on maize, which is the cause for decrease in fresh weight with increase in concentration of extracts. So the aqueous leaf, stem and rhizome extract of ginger showed inhibitory effects on all seed germination parameters like germination percentage, root length, shoot length, vigour index, percent totoxicity, fresh weight, dry weight, in maize seedlings. All these parameters were found to be decreased with increasing the aqueous leaf, stem and rhizome extract of ginger. In all parameters maximum value were recorded at control and the minimum value were recorded at 100% concentration. It can be concluded that among the leaf, stem and rhizome, more inhibitory activity were observed in rhizome extracts due to the presence of allelochemicals.

TABLE 1: Germination percentage, vigour index, tolerance index and percentage of phytotoxicity of *Zea mays L.* seedlings treated with different concentrations of stem extract of ginger

Parameters	Different concentrations of Ginger stem extract					
	Control	**20%**	**40%**	**60%**	**80%**	**100%**
Germination percentage	89.66 ±0.314[a]	79.660±0.312[b]	66.33±0.881[c]	54.33±0.821[d]	44.33± 0.614[e]	31.66±0.66[f]
Vigour index	2330.95±44.52[a]	1699.83±50.70[b]	1288.58±49.70[c]	940.65±32.20[d]	665.54± 22.26[e]	407.13± 19.80[f]
Tolerance index	100.00±0.00[a]	93.10±1.34[b]	88.17±0.91[c]	82.46±2.40[d]	76.52±3.57[e]	61.39±1.77[f]
Phytotoxicity %	0.00± 0.00[f]	3.94±1.96[e]	6.42± 2.30[d]	17.74±3.07[c]	21.30 ±4.2195[b]	30.46 ±4.2121[a]
Root length (cm)	9.76±0.39[a]	9.36±0.32[a]	8.97±0.56[b]	8.00±0.37[c]	7.65±0.01[d]	6.75±0.03[e]
Shoot length (cm)	16.23±0.36[a]	11.96±0.26[b]	10.43±0.25[c]	9.34±0.88[d]	7.08±0.30[e]	6.10±0.48[f]
Freshweight (g/plant)	0.83±0.066[a]	0.71±0.088[b]	0.63±0.0041[c]	0.52±0.012[d]	0.44±0.011[e]	0.37±0.032[f]
Dry weight (g/plant)	0.22±0.115[e]	0.23±0.006[d]	0.23±0.0021[d]	0.25±0.008[dc]	0.28±0.003[b]	0.34±0.002[a]

Mean ± SE followed by the same superscript are not statistically significant between the concentration when subjected to SPSS package ver. 14.0 according to Tukey's mean range test at 5% level.

TABLE 2: Germination percentage, vigour index, tolerance index and percentage of phytotoxicity of *Zea mays L.* seedlings treated with different concentrations of leaf extract of ginger

Parameters	Different concentrations of Ginger leaf extract					
	Control	**20%**	**40%**	**60%**	**80%**	**100%**
Germination percentage	83.66±0.333[a]	79.66 ±0.143[b]	66.33±0.821[c]	54.33±0.381[d]	44.33±0.666[e]	31.66±0.742[f]
Vigour index	2070.68±19.06[a]	1500.50±16.48[b]	1203.52±9.64[c]	758.38±25.09[d]	607.98±9.82[e]	418.99±3.24[f]
Tolerance index	100.00±0.00[a]	79.30±1.09 [b]	66.73±1.59[c]	60.67±2.74[d]	58.88±0.55[e]	45.82±1.82[f]
Phytotoxicity %	0.00±0.00[f]	3.94±1.96[e]	6.42±2.30[d]	17.74±3.07[c]	21.30±4.219[b]	30.46±4.212[a]
Root length (cm)	11.18±0.37 [a]	9.93±0.25[b]	8.88±0.07[c]	7.66±0.11[d]	7.13±0.13[e]	6.54±0.27[f]
Shoot length (cm)	13.56±0.43[a]	11.10±0.25[b]	11.06±0.21[c]	7.45±0.52[d]	6.58±0.21[e]	5.67±0.17[f]
Fresh weight (g/plant)	0.86±0.021[a]	0.75±0.011[b]	0.62±0.008[c]	0.53±0.008[d]	0.50±0.012[e]	0.42±0.006[f]
Dry weight (g/plant)	0.23±0.006[f]	0.23±0.003[e]	0.28±0.005[d]	0.32±0.003[c]	0.37±0.008[b]	0.41±0.015[a]

Mean ± SE followed by the same superscript are not statistically significant between the concentration when subjected to SPSS package ver. 14.0 according to Tukey's mean range test at 5% level.

TABLE 3: Germination percentage, vigour index, tolerance index and percentage of phytotoxicity of *Zea mays L.* seedlings treated with different concentrations of rhizome extract of *ginger*.

Parameters	Different concentrations of Ginger rhizome extract					
	control	**20%**	**40%**	**60%**	**80%**	**100%**
Germination Percentage	84.33± 0.612[a]	74.66 ±0.34[b]	64.66± 0.323[c]	49.33± 0.67[d]	40.3± 0.31[e]	28.66± 0.61[f]
Vigour index	2105.2±38.2[a]	1482.1±15.5[b]	1074.1±8.49[c]	741.69±43.9[d]	487.3±7.56[e]	293.66±20.0[f]
Tolerance index	100.00±0.00[a]	71.45±3.74[b]	59.40±1.37[c]	51.12±1.33[d]	39.3±2.57[e]	33.30±1.06[f]
Phytotoxiciy %	0.00±0.00[f]	15.86±2.88[e]	31.76±0.98[d]	35.98±2.35[c]	48.8±1.10[b]	51.48±1.55[a]
Root length(cm)	10.05±0.08[a]	8.45±0.27[b]	6.85±0.09[c]	6.43±0.28[d]	5.14±0.07[e]	4.87±0.12[f]
Shoot length (cm)	14.98±0.69[a]	11.39±0.33[b]	9.75±0.13[c]	8.58±0.48[d]	6.95±0.21[e]	5.35±0.34[f]
Fresh weight (g/plant)	0.80±0.020[a]	0.63±0.008[b]	0.53±0.015[c]	0.47±0.012[d]	0.43±0.017[e]	0.38±0.003[f]
Dry weight (g/plant)	0.18±0.012[f]	0.20±0.005[e]	0.24±0.006[d]	0.29±0.012[c]	0.32±0.010[b]	0.34±0.006[a]

Mean ± SE followed by the same superscript are not statistically significant between the concentration when subjected to SPSS package ver. 14.0 according to Tukey's mean range test at 5% level.

References

Abdul-Baki, A. A., and Anderson, J. D. (1973). Vigour determination of Soybean seed by multiple criteria. *Crop Sci*, 13 (6): pp630-633.

Agarwal, R.L. (1994). Seed technology. Oxford and IBH publishing co. New Delhi.

Albuquerque, M. B. D., Santos, R. C. D., Lima, L. M., Filho, P. D. A. M., Nogueira, R. J. M. C., Camara, C. A. G. D., and Ramos, A. D. R. (2010). Allelopathy, An alternative tool to improve cropping systems. A review. *Agron. Sustain. Dev*. 31: pp379-395.

Anonymous. (2010). Series of Crop Specific Biology Documents: Biology of Maize. Govt of India: Ministry of Environment and Forestry. 1: pp2-30.

Chiou, C.H. and Muller, C.H. (1972). Allelopathic Mechanism of *Archtostaphylous glandulosa* Variety Zazaeisis. *Am. Mid Nat*, 88: pp324-347

Chon, S., Choi, S. K., Jung, S., Jang, H. G., Pyo, B. S., and Kim, S. M. (2000). Effect of Alfalfa leaf extracts and Phenolic Allelochemicals on early seedling growth and root morphology of Alfalfa and barnyard grass. *Crop protection*. 21: pp1077-1082.

Han, C. M., Pan, K. W., Wu, N., Wang, J. C., and Li, W. (2008). Allelopathic effect of Ginger on Seed germination and Seedling growth of Soybean and Chive. *Scientia Horticulture*.116:pp 330-336.

ISTA. (1985). International rules for seed testing. *Seed. Sci and Technol*. 13: pp361-513.

Jabeen, N., and Ahmed, M. (2009). Possible Allelopathic Effects of three different Weeds on Germination and Growth of Maize cultivars. *Pak. J. Bot*. 41 (4): pp1677-1683.

Kruse, M., Strandberg, M., and Stranberg, B. (2000). Ecological Effects of Allelopathic Plants. A Review. Dept of Terrestrial Ecology. Silkeborg, Denmark. Rep.no-314:pp 1-6.

Melkania, N. P. (1984). Influence of leaf leachets of certain woody species on agriculture crops. *Indian J. Ecol*. 11: pp82-86.

Oyerinde, O., Otusanya, O., and Akpor, O. B. (2009). Allelopathic effect of *Tithonia diversifolia* on the germination, growth and chlorophyll contents of maize (*Zea mays L.*). *Academic journals Scientific Research and Essay.* 4 (12): pp1553-1558.

Raoof, K. M. A., and Siddiqui, M. B. (2012). Allelopathic Effect of Aqueous extracts of different parts of *Tinospora cordifolia* Willd. Miers on some weed plants. *J. Agric. Exten and rural Devp*. 4 (6): pp 115-119.

Singh. H.P., Batish, D. R., and Kohli, R. K. (1999). Autotoxicity: Concept, Organisms and Ecological significance. *Crit. Rev. Plant Sci*. 18: pp757-772.

Soltys, D., Krasuska, U., Bogatek, R., and Gniazdowska, A. (2013). Allelochemicals as Bioherbicides- Present and Perspectives. *Licensee Intech*. pp517-519.

Tawaha, A. M. and Turk, M. A. (2003). Allelopathic Effects of Black Mustard (Brassica nigra) on Germination and Growth of Wild Barley (Hordeum spontaneum) J. Agronomy & Crop Science 189, pp298—303

Tanveer, A., Rehman, A., Javaid, M.M., Abbas, R.N., Sibtain, M., Ahmad, A.U., Sahid, M., Zamir, I.I., Chaudhary, K.M. and Aziz, A. (2010). Allelopathic potential of *Euphorbia heliscopia L.* against wheat (*Triticum aestivum L.*), Chick pea (*Cicer arietinum L.*) and Lentil *(Lens culinaris Medic.*). *Turk. J. Agric.* 34: pp75-81.

Turner, L. G., Marshal, C. (1972). Accumulation of zinc by sub cellular fraction of root of *Agrostis tennis* sibth in relation to zinc tolerance. New Phytology, 71: pp671-676.

Valenzuela, H. (2010). Farm and Forestry Production and Marketing Profile for Ginger. *Paramount Agriculture Resources*. Hawai. pp1-12.

Willis, R. J. (1985). The historical basis of the concepts of allelopathy. *J. Hist. Biol*. 18: pp17-102.