

Antibacterial, Antidiabetic and Anticancer Activities of Natural Products of Some Medicinal Plants of Muzaffarpur District

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Abstract: - The present study of medicinal plants, widely present in different localities of Muzaffarpur district selected for the present investigation were *Tinospora cordifolia*, *Vernonia divergens* and *Mucuna pruriens*. The idea was to screen the natural products i.e. bio-ingredients of these plants in terms of antibacterial, antidiabetic and anticancer activities. Since the pharmaceutical industries stand for over-exploitation of medicinal plants resulting into their possible depletion, thus, an effective alternation for conservation and multiplication of these plants is also required in order to fulfil the present aim of investigation. A more penetrating comparative account in antibacterial, antidiabetic and anticancer activities was studied by comparing the *in vivo* and *in vitro* extracts on different parameters, such study of *in vivo* and *in vitro* extracts of these plants may lead to understand comparative efficacy of phytochemicals from both sources on the cytotoxicity assay especially in cancer study. Thus, *in vitro* extract production required the protocol to generate micropropagation of plantlets because of their annual propagation i.e. non-availability of the plants throughout the period of research activities.

Keywords: Anticancer, Biotization, Micropropagation, *Vernonia divergens*, *Piriformospora indica*.

LITRODUCTION

The natural ingredients present in medicinal plants are used in Ayurvedic 'Rasayan' to cure a number of ailments as well as to improve the immune system of body resistance against infection. In recent years, there has been resurgence in the use of herbal therapies and they are becoming increasingly popular in general population (Dhami,2013). Millions of people today use herbal therapies which are available to consumers in various forms of preparations and doses. Easy accessibility, perception of herbs as safe alternate treatment, desire for self-medication and lesser cost are several factors that has contributed to the increased use of the herbal products. Though there is a claim that it has no side effect and toxicity, yet the safety and the potential indication in human beings have to be established using modern methods. Efforts are in progress to isolate and characterize the active principles which is responsible for the hepatoprotective efficacy of these valuable medicinal plants.

With this background, the present investigation was designed to screen a few medicinal plants available in this area of District town, Muzaffarpur, namely *Tinospora cordifolia*, *Vernonia divergens* and *Mucuna pruriens* for alternative therapy. But before initiating any attempt for alternative therapy, the chemical ingredients of these plants need careful investigation on the safe use of these chemicals as drugs. Thus, pharmacological and biochemical investigations are the need of hour to elucidate the mechanism of antibacterial, antidiabetic and anticancer potentiality of these medicinal plants. India is a diabetogenic country, where considerable progress in the treatment of diabetes by synthetic drugs continues but it is associated with several limitations. Alternatively, herbal drugs have been acclaimed for their therapeutic properties in the traditional systems of medicines. *Tinospora* (Guduchi) extracts are widely used in the traditional system of medicine in the treatment of jaundice, rheumatism, urinary diseases, intermittent fevers, etc. Guduchi reduced levels of bilirubin and alkaline phosphatase. In the Indian system it is known to increase the longevity and body's resistance against various diseases. Hence the plants are used in Ayurvedic medicine to improve the immune system, memory and mental intelligence. *Vernonia divergens* is a potent sugar killer. The leaves, boiled in water are successfully administered to a large number of inhabitants in the University area, suffering from diabetes mellitus (Prakash, 2013). *Mucuna divergens*, a twinning annual plant contains the chemical compounds responsible for itching, which is a protein, mucunain (Agharkar, 1991). The seed of *M. pruriens* contains high concentrations of L-DOPA, an unusual non-protein amino acid and a direct precursor to the neuro transmitter dopamine, an important brain chemical involved in mood, sexuality and movement. *Mucuna* extract is used against a wide range of disorders, such as urinary tract, neurological and menstruation disorders,

constipation, edema, fever, tuberculosis, ulcers, (Katzenschlager et al., 2004).



Fig.1: Biotization of micropropagated *Vernonia divergens* plant

1. In vivo grown *V. divergens* in SAP garden of DRS Department of Botany, B R A Bihar University, Muzaffarpur
2. In vitro multiplied shoot clump before subculturing
3. In vitro shoot multiplication after subculturing
4. In vitro rooting in shoots during subculturing
5. *Piriformospora indica* grown on PDA medium
6. Micropropagated biotized plantlets
7. Biotized roots after maceration showing *P. indica* infection
8. 30-day old plantlet of non-biotized and biotized *V. divergens* on transfer in tray beds
9. Biotized plantlets of *V. divergens* on being shifted into highly humidified acclimatized chamber.

Vernonia divergens is an important medicinal plant which does not produce viable seeds and is propagated vegetatively. This plant, commonly known as insulin plant, is a potent sugar killer and is used as an excellent

Table 1: Effect of Adenine sulphate (25 mg/L) in combination with BAP and NAA on multiplication of shoots from shoot tip explants of *Vernonia divergens* after 25 days of MS medium containing 0.8 % agar and 5 % sucrose.

Growth regulators		Shoot formatio n [%]	No. of shoots [Explants ⁻¹]	Height of shoots [cm]
BAP	NAA			
-	-	45±1.00	1.32±0.10	1±0.01
1	-	62±1.00	5.75±0.13	1.00±0.03
2	-	70±1.50	7.63±0.25	1.25±0.01
3	-	76±1.75	10.25±0.65	1.95±0.05
1	0.5	100±0.00	20.00±0.080	3.00±0.01
2	1.0	100±0.00	25.00±1.04	4.00±0.00
3	1.5	100±0.00	15.00±0.54	3.25±0.01

Data represent the mean of 20 cultures, ± Standard Deviation (SD), where n = 3

medicine for diabetes mellitus. The plant could be micropropagated very successfully at combinations of different phytohormones. But the rate of successful transplantation of *in vitro* generated plantlets has been made to increase by a recently developed technique of biotization. It has improved the transplantation process in tobacco, cassava and many other crops with active cultures of AM fungi ¹⁰. Recently *Piriformospora indica* too has been established to have the potentiality in inducing biotization in several crop plants during *in vitro* condition ¹¹. The suitability for *P. indica* as a biotizing agent for the hardening of tissue culture raised plants has been proved ¹². Considering the property of biotization in

P. indica, attempts have been extended to biotize the *in vitro* generated plantlets of insulin plant, *V. divergens* to bring hardiness with this novel fungus in order to compete under adverse environmental conditions. Earlier, some of the plant extracts were reported to be effective against Ehrlich Ascites Carcinoma (EAC) cell lines ^{13, 14}. We, too, screened the different dilutions of ethanol extract of both *in vitro* generated plantlets and *in vivo* naturally grown garden plants of *V. divergens* ¹⁵ and *Coleus forskohlii* ¹⁶ for *in vitro* percentage cytotoxicity at different time periods. The inhibition level against EAC cell lines was found to be higher in ethanol extract of naturally grown plants as compared to that of the *in vitro* generated plants. In the present study, cytotoxicity or cell viability assay using EAC cell lines *in vitro* ^{17, 18} was carried out for investigating anticancer potentiality in the putative biomolecules present in ethanol extract of *V. divergens* especially after biotization with *P. indica*.

MATERIALS AND METHODS

Plant and microbial materials: Shoot tips (2-3 cm) as explants were excised from two-year-old *V. divergens* plant maintained in the SAP garden of DRS Department of Botany, B R A Bihar University, Muzaffarpur. The explants were washed with 5% (v/v) teepol solution for 10 min; surface sterilized with 0.2 % HgCl₂ for 2-3 min and rinsed 3-4 times with sterile double distilled water.

Explants cultured with solid MS medium ¹⁹ containing 0.8% agar, 3% sucrose and supplemented concentrations (1.0, 2.0 and 3.0 mg/L) of 6-benzylaminopurine (BAP), (0.5, 1.0 and 1.5 mg/L) of α -naphthalene acetic acid (NAA) and (25 mg/L) of adenine sulphate (ADS). The pH of the medium was adjusted to 5.8 before addition of agar and autoclaving at 121^oC. The cultures were maintained at 25±2^oC. Multiplication of shoots from the shoot tips once established on MS medium supplemented with different hormones at desirable concentrations were rooted on MS medium supplemented with IBA (1.0, 2.0 and 3.0 mg/L). Thus, obtained complete plantlets were put for hardening in tray-beds in the acclimatizer room once they were biotized with the fungus, *P. indica*.

Microbial Cultures: The fungus, *Piriformospora indica* (DSM 11827) used in the present study was grown on Potato Dextrose Broth at 28±2^oC for 10-12 d. It was affectionately gifted to our laboratory by Prof Ajit Varma, Amity Institute of Microbial Technology, Amity University, Noida, U P, through one of the co-authors (K S).

Biotization: The regenerated plants, raised through tissue culture were placed under stress by permitting biotization in polythene bags (one plantlet per bag), each containing 200 g of vermiculite and soil (1:1). Biotization of *P. indica* was carried out using broth culture containing 3X10⁴ spores (chlamydospores) along with heavy amount of mycelia per polythene bag. The procedure involved the soil drenching method in which the inoculum was made available in the vicinity of plant roots. These biotized plantlets were then transferred in tray-beds with virgin soil in acclimatizer room at 28±2^oC for 30 days with 14/10 hours light/dark conditions and 60-70% relative humidity.

Colonization: Plantlets were microscopically examined for *P. indica* colonization by staining the roots with cotton blue and lacto phenol. Population count of *P. indica* was noted by using standard serial dilution pour plate method in presence of an antibiotic (streptomycin 50 µg/mL).

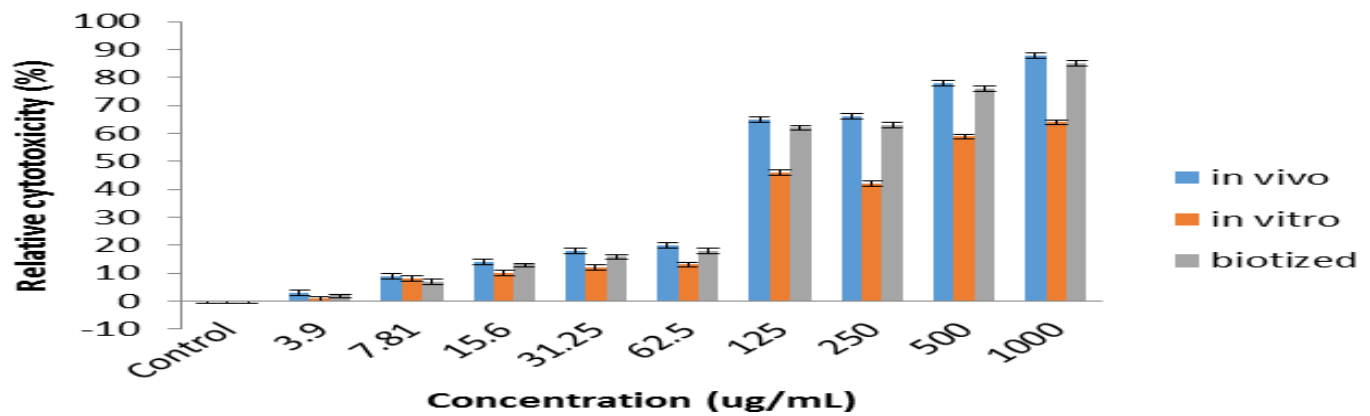


Fig. 2: Effect of different concentration of ethanol extracts of in vivo in vitro and in vitro biotized plants against EAC cell line growth inhibition (Relative Cell Cytotoxicity) in MTT assay.

Plant Biomass: Roots and shoots were washed in tap water and then in 0.1% HCl to remove adhering soil particles. Dry weights were recorded by drying root and shoot samples in an oven at 70°C for 2 days. Root and shoot length were also measured. Various parameters including per cent survival, per cent colonization of *P. indica*, population count of biotized roots, root-shoot length and dry weight as well as the length and number of leaves were recorded after 30 d of transplantation under humidified acclimatized room condition.

MTT assay: The cytotoxicity assay was done through quantitative determination of viable cells as prescribed by previous protocol²⁰. EAC cells (5×10^3 per well) were cultured on a flat bottomed 96-well plate. After 24 hrs, 48 hrs and 72 hrs of incubation (at 37°C, 5% CO₂), 20 µl of MTT stock solution was added to each well of the assay plate, which was again incubated for four hours at 37°C. The incubation of stock solution confirmed the formation of formazan crystals by the reduction of tetrazolium salt by the mitochondria of living cells. The medium was removed and 150 µl of DMSO was added to each well to dissolve the MTT metabolic product. The plates were read in ELISA plate reader at the wavelength of 540 nm. Untreated cells are used as a control of viability (100%) and the results are expressed as % viability relative to the control.

Statistical Analysis: The results were expressed as mean \pm SD. The data were analysed using one-way analysis of variance (ANOVA) and the value ($p < 0.05$) was considered as statistically significant.

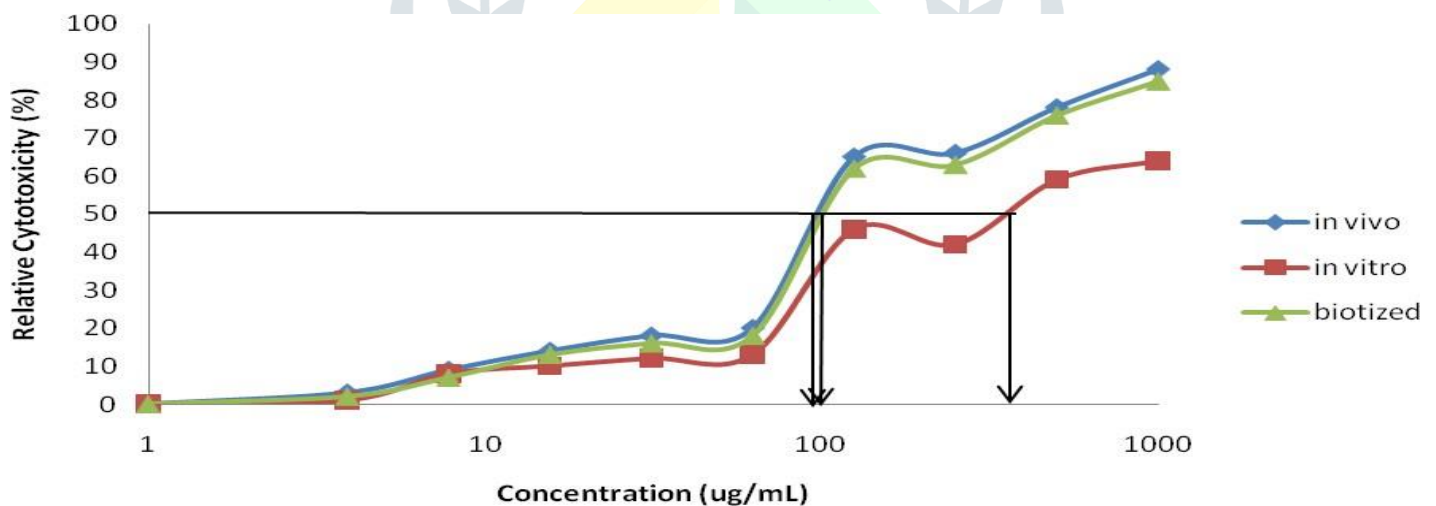


Fig. 3: Relative Cell Cytotoxicity of ethanol extracts of in vivo, in vitro and in vitro biotized plants against EAC cell line: The IC₅₀ values were extrapolated from the cytotoxicity curve at 50% of inhibition of EAC cell line after 72 hours of extract treatment.

RESULTS

Micropropagation of the plant was achieved through shoot tips as explants, which were excised from two-year-old plant of *Vernonia divergens* (Figure 1a) on MS medium supplemented with plant growth regulators at different concentrations. BAP (3mg/L) with adenine sulphate (25 mg/L) was effective for shoot multiplication but the combination with NAA (1mg/L) gave better results. Data revealed that the three good concentrations of BAP supplemented with NAA and same concentration of adenine sulphate were standardized for excellent multiplication of shoots. These concentrations were: 1mg/L BAP + 0.5 mg/L NAA, 2mg/L BAP + 1.0 mg/L NAA and 3.0 mg/L BAP + 1.5mg/L NAA. Among these, 2mg/L BAP + 1mg/L NAA along with adenine sulphate (25 mg/L) was responsible for rapid and heavy multiplication of shoots and the best morphogenic response was obtained (25-30 per explants) (Figure 1b; Table 1). Micro-plants were separated

and sub-cultured on different concentrations of IBA (Figure 1c). Attempts to develop rooting in the regenerated shoots were tried successfully by supplementing IBA (2 mg/L) (Figure 1d). With the help of *P. indica* (Figure 1e), the micropropagated plantlets were biotized and after 30 days, they were examined for colonization (Figure 1f).

Histological studies of the roots of *V. divergens* colonized by *P. indica* showed inter- and intra-cellular spread of hyphae and the formation of chlamyospores. The colonization was studied on the basis of presence of hyphae and pear shaped chlamyospores in the cortical cells of stained roots (Figure 1g). Survival rate after 30 days of acclimatization in soil was found to be maximum with *P. indica* biotization. By soil drenching method it was observed that the per cent colonization ranged from

58.0 to 78.0 within 30 days to 90 days of transplantation and per cent plant survival ranged from 86.0 to 100 in this period as compared to the control plants (non-biotized) which ranged from 66.0 to 68.0 (Figure 1h, Table 2). It established the impact of colonization since all the treated plants transferred after one month under stress of *P. indica* of growth were survived (Figure 1i).

Significant increase in length and dry weight of root and shoot as well as number of lateral roots was observed due to colonization as compared to the uninoculated control plants. An increase in shoot length and shoot dry weight was recorded *in vitro* plants biotized with *P. Indica* after 30 d of growth in humidified acclimatized room. Leaf of *V. divergens* deserved special attention since it was frequently used by diabetic patients. Therefore, it was conceived to observe the effect of *P. indica* on the length and no. of leaves of micropropagated plants. The length of leaf was 5.6 cm as compared to 3.5 cm in control. Similarly, the number of leaves was 7.00 per biotized plant as compared to 4.25 in control (Table 3).

The concentrated ethanol extracts from three sources, viz., *in vivo* natural, garden plants, *in vitro* generated plantlets (non-biotized) and *in vitro* generated biotized plants were screened for *in vitro* percentage cytotoxicity at 72 hours of treatment. The profile of EAC cell growth inhibition after being treated with plant extracts of three sources mentioned above could be observed (Figure 2). It was found that all the three extracts showed slight cytotoxicity at the concentration below 125 µg/mL. At higher concentrations (125, 250, 500 and 1000 µg/mL), the *in vivo* plant extract was inhibitory on EAC mouse cell lines, the percent inhibitions were 65, 66, 78 and 88%, respectively whereas there was 20% less inhibition in ethanol extract of *in vitro* plantlets as reported previously¹⁵. However, the level of inhibition in EAC cell lines was almost restored (62, 63, 76 and 85 µg/ml) in *in vitro* generated biotized and acclimatized plantlets (Figure 2), which were allowed to grow under stress of colonization of the fungus, *P. indica*. The trend was also found to be similar in the IC₅₀ value in *in vivo* and *in vitro* biotized plants; it was 100 and 95.5 µg/ml, respectively, whereas the IC₅₀ value was raised to 660.6 µg/ml (Figure 3) in *in vitro* non-biotized plant extract. The ethanol extracts significantly ($p < 0.05$) reduced the viability of EAC cells after incubation for 72 hours in a manner that was directly related to the concentrations (0 to 1000 µg/ml) of the extracts in all the three sources.

DISCUSSION

The present work is an attempt to study the antibacterial, antidiabetic and anticancer activities of secondary metabolites, isolated from selected medicinal plants employing cell and tissue culture techniques. Due to ever growing demand of medicinal plants especially during off season, the tissue culture techniques have been employed for rapid and mass-multiplication and conservation. Plant micropropagation via direct shoots regeneration allowed large scale multiplication of plantlets *in vitro* by preventing clonal variation as opposed to regenerated from calli alone, which often leads to somaclonal variation (Reddy et al., 2001).

In general, micropropagated plants, exhibit high mortality rates upon their transfer to soil. Even 5% mortality causes a huge loss during commercial plants production. The humidified acclimatized room and field possess relatively lower humidity, higher light intensity and septic environment that are stressful to micropropagated plants as compared to *in vitro* conditions²⁴. The benefit of any micropropagation system can be fully realized only by the successful transfer of plantlets from tissue culture vessels to the ambient conditions found *ex vitro*.

Biotization of micropropagated *V. divergens* with *P. indica* increased resistance of plants from stresses at the time of transplantation, thus protected micropropagated young plantlets from 'transplantation shock'. Plant growth and biomass is greatly influenced by nutrients and environmental conditions⁵. *P. indica* too helped in nutrient uptake by extending its hyphae in the rhizospheric region where even finest roots cannot reach. Thus, role of this probiotic fungus in nutrient uptake and growth of micropropagated *V. divergens* was found to be effective studies in field conditions.

Biological assay such as tumor cell cytotoxicity is a sensitive method to scrutinize the anticancer principle present using EAC cell lines *in vitro*¹⁷. The significant ($p < 0.05$) decrease in the cancer cell viability with increasing dose and time indicates that the ethanol extracts are cytotoxic even in cultured plant tissues, if exploited¹⁶. It measures cell membrane integrity by determining mitochondrial activity through enzymatic reaction on the reduction of MTT to formazan²⁵. The above results confirm the production of secondary metabolites with anticancer properties¹⁷, even during the morphological differentiation at low concentration¹⁶, but it can be enhanced by new biotechnological interventions such as fungal mediated cultures²⁶. *Vernonia divergens*, growing in the field conditions (*in vivo*) acquires the biochemical pathway to produce anticancer compounds. These compounds may be altered during *in vitro* conditions of tissue culture but under stress of the colonization of a fungus even in *in vitro* condition, the pathway to produce the anticancer compounds may be restored. The present findings support the contention that plants under stress of any external agents, either heavy metals

or microbes start producing secondary metabolites with medicinal properties. These medicinal compounds have been found to be clinically active against various types of cancer cells. Further research in this area may lead to better treatment of cancer. Phytochemical analyses of the *in vivo* and *in vitro* derived plantlets confirmed the presence of alkaloid, phenols, tannins, flavanoids, glycosides and steroids (Unpublished observations). Pharmacognostical studies and evaluation of total phenolic and flavanoid contents²⁷ of this traditionally used antidiabetic plant species is in progress.

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