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Antimicrobial activity of indigenous wildly growing plants: Potential source of green antibiotics

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Antibiotics are an important class of pharmacological agents used for treating infections, a major cause of human morbidity and mortality. Although antibiotics were first isolated from fungi and bacteria but over the years more and more synthetic antibiotics are flowing in market. During the last two decades, the development of drug resistance as well as the appearance of undesirable side effects of certain antibiotics has lead to the search of new antimicrobial agent. There is ample of documented evidence which shows antibiotic properties in plant extracts. The present study was done to assess the antibacterial and antifungal activity of wildly growing indigenous plants. Aqueous and ethanolic extracts of different parts of *Oxalis amara, Argemone maxicana, Datura inoxia, Calatropis procera, Amranthus albus, Pithecellobium dulce, Ziziphus mauritiana, Croton bonplandianum, Cannibus sativa, Leucaena leucophela, Andographis peniculata* were taken for study, against pathogenic bacteria *Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus* and fungus *Candida albicans.* Results were observed and calculated by their zone of inhibition after 24 h by agar plate gel diffusion method. The plants have shown strong antibacterial and antifungal activities for different microorganisms. This laboratory experiment has shown that plant extracts are effective against microbes and their active compounds can be promising agents for developing novel antibiotics, that is, green antibiotics.

Key words: Wildly growing plants, secondary metabolites, antimicrobial activity, pathogenic bacteria, agar plate gel diffusion method, zone of inhibition.

INTRODUCTION

Currently, there are increasing incidents of infections due to evolution of new/mutant pathogens (Ahmed, 2011) and at the same time, some deadly diseases like cancer, human immunodeficiency virus-acquired immunodeficiency syndrome (HIV-AIDS), different bacterial diseases like-tuberculosis, leprosy are still prevailing in our society. Bacterial strains showing resistance against antibiotics are increasing day by day (Davis, 1994). For example, multi-drug resistant tuberculosis (MDR-TB) which is resistant at least to isoniazid and rifampicin and complete drug resistant tuberculosis (XDR-TB) that is resistant to the most powerful first line anti-TB drugs. So the doses are regularly increasing or given in combination, that is, one drug to check resistance and the other as antibiotic (for example, amoxicillin + sulbactum). During the last two decades, the development of drug resistance by different bacterial strains as well as the appearance of undesirable side effects of certain antibiotics has lead to the search of new antimicrobial agent. Presently, maximum antibiotics in the market are synthetic, not from original

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Abbreviations: MDR-TB, Multi-drug resistant tuberculosis; **XDR-TB,** complete drug resistant tuberculosis; **aq,** aqueous; **eth,** ethanolic; **ZOI,** zone of inhibition.

bacterial/fungal source. Industries are not focusing on this field due to time consuming process and are more interested in making proven formulations, mainly synthetic antibiotics. Even the WHO recently warned that the world is staring at a post-antibiotic era, when common infections will no longer have a cure. The organisation compared antibiotic resistance to be as bad as terror threat.

There are 250,000 to 500,000 species of plants on earth (Cowan, 1999) out of which only 1-10% are used as food for both humans and other animal species, however more than these are used as medicinal purpose. About 85,000 valuable medicinal plant species world - wide are reported, (Devi et al., 2009; Liu and Wang, 2008), but this is also true that most of the wildly growing plants (both lower and higher) which show medicinal and other enormous qualities are not properly investigated. They are being used by local / tribal people for different purposes. On the other hand, due to heavy industrialization and urbanization, there is heavy loss of different plant species day by day on our biosphere. Use of herbal plants as drugs in our Ayurvedic, Homeopathic, Unani and Chinese system is as old as civilization. 60% of the world's population exclusively rely on traditional medicine (plant extract) for their primary healthcare needs, (Fransworth, 1994). Many researchers have examined long-established uses of medicinal plants, but only a few studies have lead to these ethno-botanical findings with laboratory job to confirm the real antimicrobial property of these plants (Bhattarai et al., 2006; Bhattarai et al., 2008; Shakya et al., 2008). Even today, formulations from plants are mainly based on extract of plants and not as specific compound. Plants produce different types of secondary metabolites. These metabolites often play an important role in plant defence against herbivory and other interspecies defences. Humans use secondary metabolites as medicines, flavourings, and recreational drugs. Around 12,000 secondary metabolites have been isolated, a number estimated to be less than 10% of the total (Cowan et al., 1999). According to one report, although about 1,700 types of natural antibiotics are known to exist, scientists did not have a detailed understanding of how they work. There are many reports on antibacterial properties, but they are mainly on proven medicinal plants (Devi et al., 2009; Ali et al., 2012), essential oils (Matosyoh et al., 2009; Evarando et al., 2005), or on single plant (Ahmed, 2011; Chandran and Balaji, 2008; Kausar et al., 1995).

There are very few reports on comparative antibacterial properties of wildly growing plants and no report on indigenous plants from northern plains of India. So, here we have investigated eleven wildly growing plants which blooms in the same season, that is, summer (March to July) in northern plains of India. An effort has been made to find out the potential of these wildly growing plants on growth of some common pathogens, affecting human populations. The aim of the present study was to find out whether plants growing in same season and at same place, can be used to prepare herbal antibiotics either singly or in combination with other plant extracts.

MATERIALS AND METHODS

Sample collection and preparation of plant extracts

Eleven different wildly growing plant species (*Oxalis amara, Argemone maxicana, Datura inoxia, Calatropis procera, Amranthus albus, Pithecellobium dulce, Ziziphus mauritiana, Croton bonplandianum, Cannibus sativa, Leucaena leucophela, Andographis peniculata)* were collected from nearby area of Amity University campus, Lucknow. The plant parts viz. leaves, flowers, fruits and root, were washed thoroughly with tap water followed by distilled water to remove the dust particles and allowed to air dry at room temperature. The plant parts were made into dried powder with the help of liquid Nitrogen and these powders were stored at -20°C till further use.

For preparing ethanolic and aqueous extracts, 1 gm of dry powder from each plant part was taken separately and mixed with 10 ml ethanol (Merck, India) or water, respectively. The mixture was macerated in mortar and pestle and kept for 48 h, to ensure maximum metabolite extraction. The final concentration was maintained as 0.1 gm/ml.

Test organisms

Four common human pathogens - *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Candida albicans* were taken for the study. The organisms were made as stock in nutrient broth, maintained by sub culturing on nutrient agar at regular weekly interval and used throughout the study.

Nutrient broth and nutrient agar (HiMedia, India) were used to grow and maintain the bacterial cultures. The media were prepared as per the supplier's instructions. Lyophilized cultures of *S. aureus* ATCC 11632, *E. coli* ATCC 10536, *P. aeruginosa* ATCC 10145 and *C. albicans* ATCC 10231 were obtained from HiMedia Ltd., India. For organism preparation, the lyophilized culture was mixed in 2.0 ml of distilled water. 100 µl of the suspension was mixed in 10 ml nutrient broth and grown overnight at 37°C. Cells were harvested by centrifuging at 10,000 rpm for 10 min at 4°C. Washed cells were resuspended in nutrient broth and optical density was adjusted to 0.1, corresponding to 10^8 CFU/ml at 600 nm. This cell preparation was used for antimicrobial study.

Antimicrobial activity assay

The gel diffusion method was carried out on nutrient agar plates to assess antimicrobial activity assay. Nutrient agar media was prepared as per the supplier's instruction and sterilized by autoclaving at 121°C for 15 min. On these plates, wells of 8 mm size were dug with the help of a sterile borer. Each plate had four wells at equal distance. 20 µl of bacterial or fungal culture was spread evenly on respective plates on which the antibacterial and antifungal activity was to be tested. For each pathogen as well as for plant sample, separate plates were prepared. In each plate, 100 µl of aqueous (aq) and ethanolic (eth) extracts prepared from same plant part, were loaded. These plates were incubated for 24 h at 37°C. Antibacterial or antifungal activity of each extract was expressed in terms of zone of inhibition (diameter in mm). Each experiment was repeated three times and mean of all values was taken. Appropriate controls - Gentamycin (HiMedia, India; for *P. aeruginosa, E. coli)*, erythromycin (HiMedia, India; for *S. aureus)* and nystanin (Hi Media, India; for *C. albicans)* were put with each

Table 1. Antimicrobial activity of plants species calculated on the basis of their zone of inhibition against test organisms *E. coli, P. aeruginosa, S. aureus* and *C. albicans.*

S/N	Plant name	Part used	Extract	Test organisms			
				E. coli	*P. aeruginosa*	*S. aureus*	*C. albicans*
1	*Oxalis amara*	Leaves	aq				
			eth	+	+		+
2a	*Datura inoxia*	Leaves	aq	++		++	
			eth	+		+++	
2b	*Datura inoxia*	Fruits	aq				
			eth		+		
2c	*Datura inoxia*	Root	aq		++		
			eth		++		
2d	*Datura inoxia*	Flower	aq	++	++		
			eth	++	+		
3a	*Argimone mexicana*	Fruits	aq	++			
			eth	+		+	
3b	*Argimone mexicana*	Leaves	aq				
			eth				
4	*Calatropis procera*	Fruits	aq	+	+	+	++
			eth	+	+	+	
5	*Amaranthus albus*	Leaves	aq		+	+	
			eth		+	++	
6	*Pithecellobium dulce*	Leaves	aq		++		
			eth		+	++	
7	*Zizipus murtriana*	Leaves	aq		++	+++	+
			eth		++	+	
8	*Croton bonplandianum*	Leaves	aq		+ +		
			eth		+		
9	*Cannabis sativa*	Leaves	aq		+	++	
			eth		+	+++	
10	*Leucaena leucophela*	Leaves	aq	+	+		
			eth	++	++		
11	*Andrographis peniculata*	Leaves	aq	++	++	+	
			eth	+			+

Aq, Aqueous; eth, ethanolic. Zone of inhibition (ZOI) is described as (i) 0 - 10 mm (+ or mild), (ii) 10 - 15 mm (++ or moderate), (iii) >15 mm (+++ or strong).

set of experiment. The antimicrobial activity expressed as zone of inhibition (ZOI) was measured in mm and interpreted as (i) 0 - 10mm (+ or mild), (ii) 10 - 15 mm (++ or moderate), (iii) >15mm (+++ or strong).

RESULTS

Eleven wildly growing plants were selected randomly and included in the study. Table 1 shows antimicrobial activity of plants species calculated on the basis of their zone of inhibition against test organisms *E. coli, P. aeruginosa, S. aureus* and *C. albicans*. *O. amara* showed mild antimicrobial activity against *E. coli*, *P. aeruginosa*, *C. albicans* in its ethanolic extract (Table 1; Figures 1, 2 and 4). Zone of inhibition (ZOI) against this bacterium was found to be 7.5, 6.5 and 7.5 mm, respectively, represented as + sign. However no activity was found in its aqueous extract. Extracts from different parts (leaves, fruits, roots and flowers) of *D. inoxia* were found to have antimicrobial potential, showing mild to strong activity (Table 1). Aqueous extract of leaves showed moderate antibacterial effect against *E. coli* (ZOI - 12.8 mm) and *S. aureus* (ZOI - 10.8 mm, Table 1; Figures 1 and 3) and represented as ++, however its ethanolic extract has given strong result against *S. aureus*. Zone of inhibition was found to be 15 mm and given +++ sign. This extract showed mild effect against *E. coli* (8.1 mm). Aqueous extract of fruit of *D. inoxia* had no antibacterial effect, with its ethanolic extract having mild effect (6.8 mm) on *P. aeruginosa*. Root extract of *D. inoxia* was found to have mild to moderate effect against *P. aeruginosa* (9.5 mm-aq and 11.2 mm-eth) only. Both aqueous and ethanolic extract from

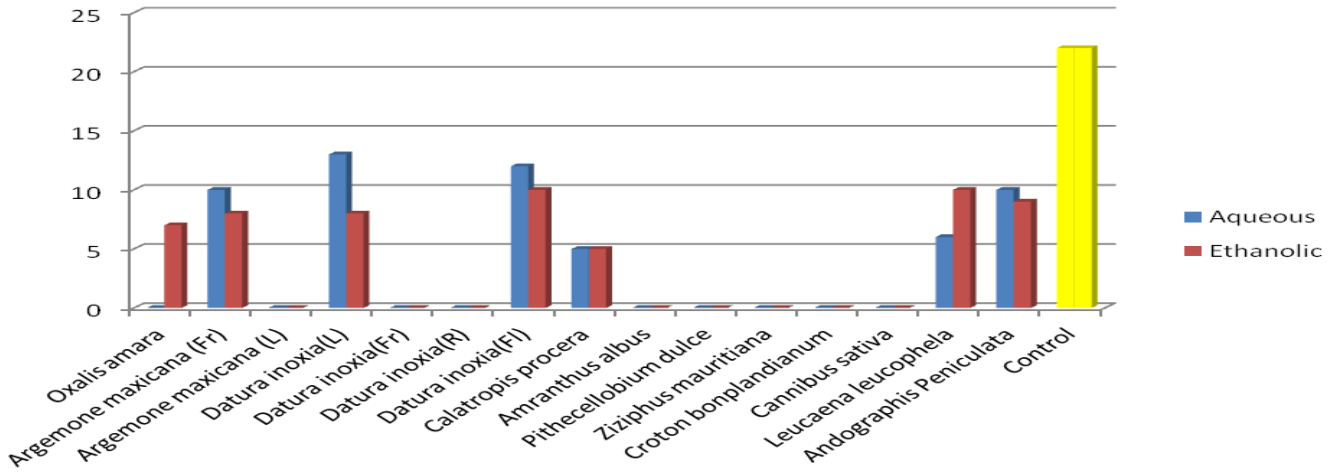

Figure 1. Zone of inhibition determined against *E. coli* in ethanolic and aqueous extracts of plants.

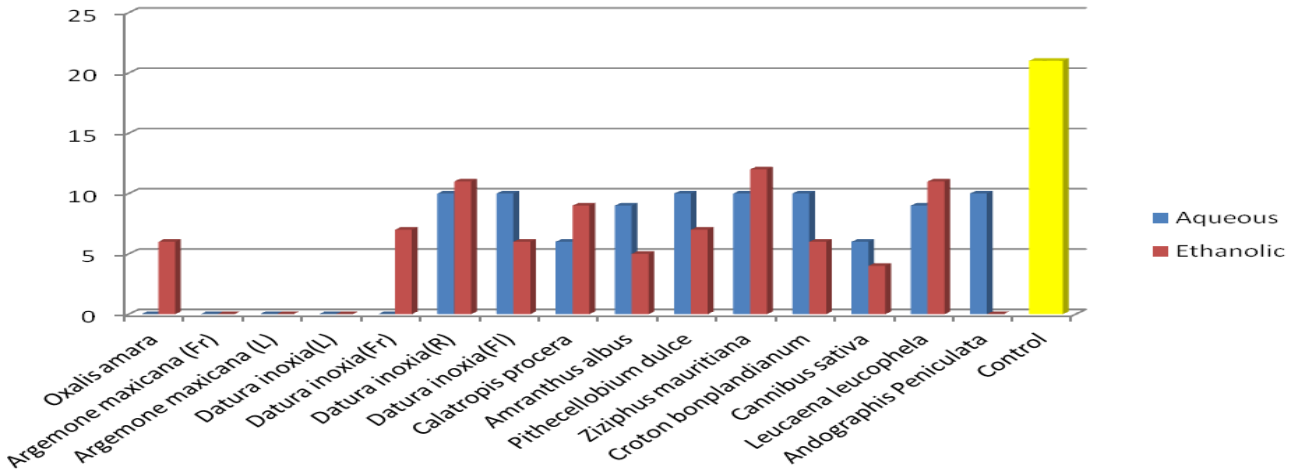

Figure 2. Zone of inhibition determined against *P. aerugenosa* in ethanolic and aqueous extracts of plants.

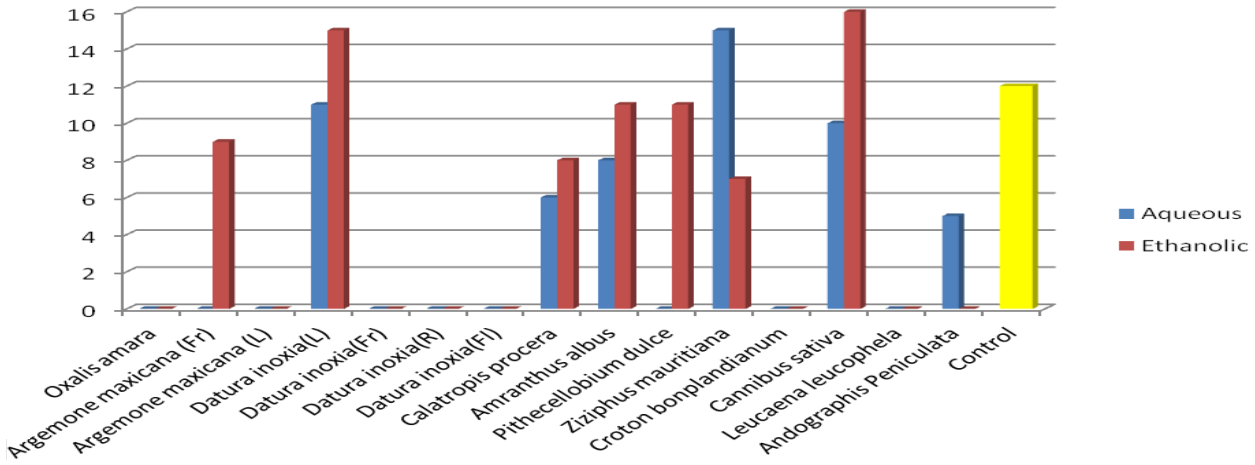

Figure 3. Zone of inhibition determined against *S. aureus* in ethanolic and aqueous extracts of plants.

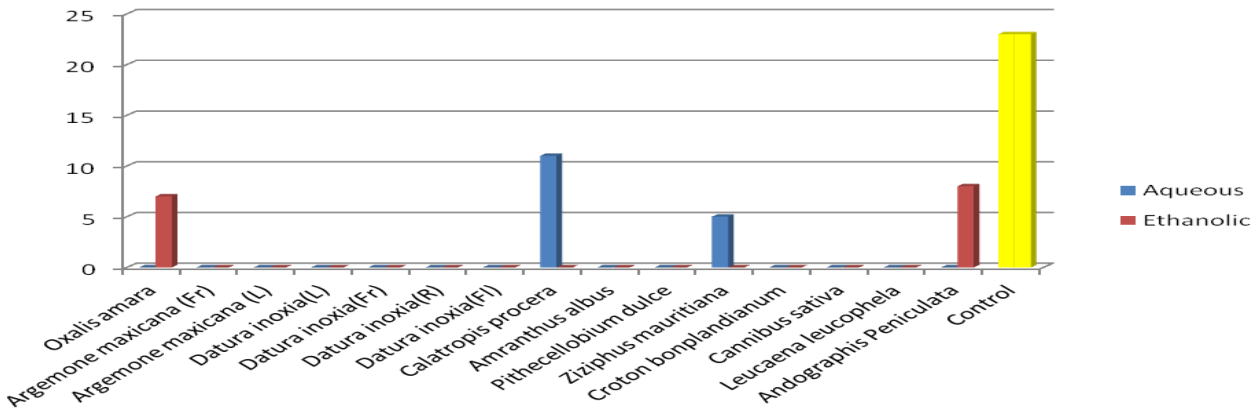

Figure 4. Zone of inhibition determined against *C.albicans* in ethanolic and aqueous extracts of plants.

D. inoxia flower was found effective (mild to moderate) for *E. coli* (11.7 mm-aq, 10.0 mm-eth) and *P. aeruginosa* (10.0 mm-aq, 5.9 mm-eth; Table 1, Figures 1 and 2). Fruit extract in ethanolic phase was found mildly effective against *P. aeruginosa* (7.2 mm) only. In the present experiment, *A. mexicana* (fruit) gave mild to moderate results against *E. coli* (10.0 mm-aq, 7.5 mm-eth) and *S. aureus* (8.8 mm-eth; Table 1, Figure 1 and 3). However, it was not found effective against *P. aeruginosa* and *C. albicans*. Our results show that *C. procera* (fruit extract) was effective against all tested microorganisms (with ZOI of 4.8, 5.6, 5.8 and 10.7 mm for *E. coli, P. aeruginosa, S. aureus* and *C. albicans*, respectively) in its aqueous extract, whereas its ethanolic extract was only mildly effective against all the test organisms (4.8, 8.8 and 7.8 mm, respectively), except *C. albicans* (Table 1, Figures 2 and 3). Its extract from leaves did not have any activity at all. Leaves of *A. albus* was found effective against *P. aeruginosa* (8.1 mm-aq, 4.8 mm-eth) and *S. aureus* (7.7 mm-aq, 10.8 mm-eth; Table 1, Figures 2 and 3). However it did not show any activity against *E. coli* and *C. albicans.* Leaves of *P. dulce* in aqueous extract was found to have antibacterial properties against *P. aeruginosa* (10.0 mm), whereas in ethanolic extract it was found to be inhibitory against *S. aureus* (10.7 mm). Leaves of *Z. mauritiana* (aq) showed inhibitory action against growth of all test organisms except *E. coli* (Table 1, Figures 2, 3 and 4). Whereas its ethanolic extract was effective moderately against *P. aeruginosa* (12.2 mm) and mildly against *S. aureus* (6.8 mm; Table 1, Figures 2 and 3). In our experiment, leaves of *C. bonplandianum* (aq and eth) were effective against only *P. aerugenosa* (10.0 and 5.9 mm, respectively; Tables 1 and 2). Aqueous and ethanolic extracts of *C. sativa* leaves had inhibitory effect against *P. aeruginosa* (6.0 and 4.2 mm, respectively) and *S. aureus* (10 and 16.0 mm, respectively; Tables 1 and 2; Figures 2 and 3). Leaves extract of *L. leucophela* was found effective against *E. coli* (5.8 mm-aq, 10 mm-eth) and *P. aeruginosa* (8.1 mm-aq, 11.0 mm-eth; Tables 1 and 2; Figures 1 and 2). *A. paniculata* leaves showed inhibitory action against growth of all test organisms. In aqueous extract it was found effective against *E. coli* (10.0 mm), *P. aeruginosa* (10.0 mm) and *S. aureus* (4.9 mm). In ethanolic extract, it showed inhibitory activity against *E. coli* (8.0 mm) and *C. albicans* (7.1 mm; Tables 1 and 2; Figures 1 and 4).

In Table 2, plants are categorized according to their antimicrobial activity against one, two, three or all four test organisms. *A. paniculata* and *C. procera* was found to be effective against all four test microorganisms. *O. amara* and *Z. mauritiana* were found to have antimicrobial effect against three out of four test microorganisms. *O. amara* was effective against *E. coli, P. aeruginosa,* and *C. albicans* whereas *Z. mauritiana* having inhibitory effect against *P. aeruginosa, S. aureus* and *C. albicans*. Some plants like *L. leucophela, A. albus, C. sativus, P. dulce, A. mexicana, D. inoxia* had their activity against two microorganisms (Table 2). *C. bonplandianum* showed its activity against single microorganism, that is, *P. aeruginosa.*

Figures 1, 2, 3 and 4 are showing comparative results of all test plants for each microorganism along with their control. *E. coli* was found to be inhibited by aqueous and ethanolic extract of *D. inoxia* (leaves and fruit), *L. leucophela, A. peniculata, A. maxicana* (fruit extract), *C. procera* and also by ethanolic extract of *O. amara* leaves (Figure 1). *P. aeruginosa* was found to be inhibited by both aqueous and ethanolic leaf extract of several test plants (Figure 2). These are *A. albus, P. dulce, Z. mauritiana, C. bonplandianum, C. sativa, L. leucophela, C. procera* (fruit extract), *D. inoxia* (root and flower extract). Aqueous leaf extract of *A. peniculata*, ethanolic extract of *O. amara* leaves and fruit extract of *D. inoxia* also proved to be effective against this bacterium. Figure 3 shows the inhibition profile of *S. aureus* with various plants extracts, which shows that leaf extract (ethanolic and aqueous) of *D. inoxia, A. albus, Z. mauritiana, C. sativa* and fruit extract of *C. procera* have significant

Table 2. List of plants according to their antimicrobial activity against one, two, three and all four test organisms.

All test microorganisms	Three test microorganisms	Two test microorganisms			One test microorganisms
		E. coli + P. aeruginosa	***P. aeruginosa + S. aureus***	***E. coli + S. aureus***	
Calatropis procera	*Oxalis amara (E. coli, P. aeruginosa, C. albicanas)*	*Leucaceana leucophela*	*Amaranthus albus*	*Argimone Mexicana*	*Croton bonplandianum (P. aeruginosa)*
Andrographis peniculata	*Zizipus maurtiana (P. aeruginosa, S. aureus, C. albicanas)*		*Pithecellobium dulce*	*Datura inoxia*	
			Cannibus sativus		

effect on the organism. This bacterium is also found to be inhibited by aqueous extract of *A. peniculata* (leaf), ethanolic extract of *P. dulce* (leaf) and *A. maxican* (fruit)**.** *C. albicans* showed resistance against *A. maxicana, D. inoxia, A. albus, P. dulce, C. bonplandianum, C. sativa, L. leucophela* in both aqueous and ethanolic extract. This is also inhibited by the ethanolic leaf extract of *O. amara* and *A. peniculata* and aqueous extract of *Z. mauritiana* leaf and *C. procera* fruit extract (Figure 4).

DISCUSSION

For this study, four common pathogens, *E. coli, S. aureus, P. aeruginosa, C. albicans* were included because of their infection causing ability, ubiquitous presence and survival in different environment. These bacteria are also gaining attention due to their increasing drug/antibiotic resistance, reported by many workers. Most known antibiotics have become ineffective for them. *E. coli* is harmful, and in humans it can cause problems like food poisoning and urinary tract infection. Its increasing drug resistant behaviour was shown by Totsika et al. (2011) and Tadesse et al. (2012). Though a common bacterium, *P. aeruginosa* can infect damaged tissues and colonize body organs like lung, urinary tract and kidneys. Its increasing drug resistant behaviour was reported by Pellegrino et al. (2002) and Harris et al. (1999). *S. aureus* is responsible for a range of skin infections viz. pimples, boils as well as life threatening diseases like pneumonia, meningitis, toxic shock syndrome. Reports from all over the world are showing its conversion as multiple drug resistant (MDR) strain (Kaatz et al., 2005). *C. albicans* is a causal agent of opportunistic oral and genital infection, called candidiasis in human beings. Its drug resistant problem has been shown by many workers (Goldway et al., 1995).

These microorganisms, which are already known to be multi resistant to drugs, have shown significant inhibition by plants extracts. This is a positive sign to develop herbal/green antibiotic. Almost all experimental plants showed mild (+) or, moderate (++) to significant (+++) antimicrobial activity by their ethanolic and aqueous extracts. In this experiment we have observed that, although plants were collected randomly but surprisingly all studied plants showed antibacterial properties at least against one bacterium, while many were showing broad spectrum antibacterial properties. This suggested that nature has given answer to the problem of drug/antibiotic resistance. *C. procera* and *A. peniculata* were found to be the most promising as both showed strong antibacterial and antifungal properties. *C. procera* also known as *"*Madar*"* belongs to family Asclepiadaceae. Its traditional uses have been in skin disease, leprosy, fever, rheumatism, cold, eczema, diarrhoea and as wormicide, antimicrobial (Verma et al., 2011; Kareem et al., 2008). Our result also showed that *C. procera* (fruit extract) have more antibacterial activity as compared to its control. This shows high potentiality of this plant in preparing herbal antibiotics. *A. paniculata* or Kalmegh (family Acanthaceae*)* has been used traditionally used as anti-hepatotoxic, antibiotic, antimalarial, anti-inflammatory, anti snake venom, anti-pyretic among others (Mishra et al., 1992; Saxena et al., 1998; Kumar et al., 2004; Burgos et al., 2009). Its extract showed wide spectrum antimicrobial properties in our experiment. *O. amara* or "Khatti booti" of family Oxalidaceae and *Z. mauritiana* or "Jungali ber" of family Rhamnaceae showed their antimicrobial activity against *E. coli*, *P. aeruginosa*, *C. albicans.* Raghavendra et al. (2006) have shown that antibacterial activity of *Oxalis* is due to the presence of phenolic compounds. *Oxalis* is also known as good appetizer, for removal of kapha, vata and pitta, to cure dysentery, diarrhoea and skin diseases (Kirtikar and Basu, 1975; Raghavendra et al., 2006). *Z. mauritiana* is found to be effective in asthma, fever, cuts, ulcers, nausea and vomiting (Ahmed, 2011; Michel, 2002; Abalaka et al., 2010). In the present experiment, growth of all test organisms except E. coli was found to be inhibited by Z. Mauritiana. *Cannibus sativa* or *"*Bhang"

belongs to family Cannabaceae and is being used as anesthetic, antispasmodic, analgesic, narcotic, sedative, and as tonic (Giovanni et al., 2008; Ali et al., 2012; Kausar et al., 1995). This has shown more antibacterial activity than control. Another plant used in the present study was *Amaranthus* or **"**Chaulai" (family: Amaranthaceae) also used as vegetable as a good source of protein and many nutrients, such as vitamin A and C. It has also been used traditionally in the treatment of menstrual disorders, eruptive fevers and eczema (Ayethan et al., 1996). In a separate study, *Amaranthus* extracts had shown broad spectrum anti-bacterial activity, but were inactive for the test fungi (Maiyo et al., 2010). This is in accordance with our results. *P. dulce* (family**:** Mimosaceae) also known as "jungle jalebie" has been used as antioxidant, antifungal and antibacterial, as liver protective drug, in intestinal disorders, diabetes, ulcers among others (Chandran and Balaji, 2008; Nagmoti et al., 2012; Gomathi et al., 2011). Sawasdipuksa et al. *(*2011) have demonstrated antifungal properties of *P. dulce* plant, which was found to be due to lysozyme from seeds. The leaf extracts of *C. sativa, A. albus* and *P. dulce* showed their antibacterial properties mainly against two test organisms *P. aeruginosa* and *S. aureus* in our study.

Among other plants used in the study is *L. leucophela or* "Sub-bool" from family Fabaceae. Its leaf extract was found to be effective against *E. coli* and *P. aeruginosa*. Traditional uses are as anti-diabetic, fodder for cattle's, green manure and biomass. Aderibigbe et al. (*2*011) had investigated antimicrobial activity and pharmaceutical properties of seed oil of *L. leucocephala* and found concentration dependent acivity against Gram positive and Gram negative bacteria. Chanwitheesuk et al. (2001) have also reported antioxidative properties of the plant. *A. maxicana* also known in India as **"**Shialkanta, Satyanashi, Pili katili" belongs to family Papaveraceae and has immense traditional uses. This plant is used in treatment of malaria, jaundice, eye infections, relieving kidney pain; to help expel a torn placenta, cleanse the body after parturition. The extract of plant has also been traditionally used to destroy worms, treat warts, cold sores, cutaneous infections, skin diseases and as antibacterial (Osho and Adetunji, 2010; Wilcox et al., 2007; Bhattacharjee et al., 2006). In the present experiment, fruit extract was found effective against *E. coli* and *S. aureus*. Extracts from different parts (leaves, fruits, roots and flowers) of *D. inoxia* were found to have antimicrobial potential, showing mild to strong activity. Other workers have also demonstrated antibacterial properties of *D. Inoxia*, family Solanaceae (Jamdhade et al, 2010; Okwu et al., 2009). The whole plant is antiseptic, narcotic, analgesic, psychedelic, antispasmodic, sedative and is useful for asthma, arthritis (Bhattacharjee, 1998), as narcotic and antispasmodic. Our result shows that phytocompound present in all parts of *D. inoxia* (except leaves) is effective for Gram -ve strains, but not for gram +ve strains. *C. bonplandianum* (family: Euphorbiaceae*)* is also known as Ban tulsi in India. The various applications of plant include antihypertensive, for treatment of skin disease, cut, wound, antiseptic, antidote and antimicrobial (Jeeshna et al., 2011; Divya et al., 2011). In our experiment, its leaf extract was found effective against *P. aeruginosa.* Our result showed that *S. aureus* bacteria can be inhibited more effectively with some plant extracts (*C. sativa, Z. mauritiana, D. inoxia*) than control.

These test organisms were found to be inhibited by plant extracts by other workers also (Nascimento et al., 2000; Aibinu et al., 2007; Sakthi et al., 2011). Our experiment and various other researchers (Devi et al., 2009; Shakya et al., 2008) have shown antibacterial activity of different wildly growing plants and thus possibility of extraction of drugs from them. Being very hardy in nature, there may be hidden molecules in these plants which can be the answer to many health related problems like acquired immune deficiency syndrome (AIDS), cancer, tuberculosis and other bacterial infections. We have also found out plants showing same antibacterial properties, which may help in our future work to formulate drug by mixing the compounds from two or more plants. Our results also show that very few plants have antifungal properties, while maximum plants have shown antibacterial activity. Fungi have different organization (eukaryoic cell, different cell wall organization) as compared to bacterial system (prokaryotic system), so the compound which is working against bacterial system, may not be effective against fungal system. The anti-microbial activity shown by our experimental plants in aqueous extract may be due the secondary metabolites like anthocyanin, tannins, saponins, terpenoids, polypeptides and lectins, whereas in ethanolic extract nature of compound may be of tannins, polyphenols, polyacetylines, flavonoids, terpenoids, sterols and alkaloids (Tiwari, 2011). The potential antimicrobial properties of plants are found to be related to their secondary metabolites having complex structures including tannins, phlobatannins, alkaloids, coumarins, cardiac glycosides, terpenes, phenylpropanes, organic acids, flavonoids, isoflavonoids and saponins (Evarando et al., 2005; Matasyoh et al., 2009).

Conclusion

By comparative study of wildly growing plants, we find some plants like *D. inoxia*, *C. procera, A. peniculata* had very strong broad spectrum antibacterial properties while other plants have shown mild to moderate antibacterial activity. So we can say that these wildly growing plants may have high potential for herbal antibiotics. Drugs / antibiotics can be made from these plants singly or in combination of compounds from two or more plants. There is urgent/great need to work more on these plants,

that is, up to the compound and formulation level. Sound scientific methods are required to assess suitability of existing agents as antibiotics for human use. Phytocompounds based drugs will be more cost effective, easily affordable to the common people and can be used as antibacterial, antifungal, anticancerous among others. As extracts obtained from natural sources have complex structure, we can hypothesize that these agents may have lesser cases of bacterial resistance. The future prospects of present research work will include purification of extracts characterized by several methods like high performance liquid chromatography (HPLC), nuclear magnetic resonance (NMR), gas chromatography-mass spectrometry (GC-MS) and electrospray ionization tandem-mass spectrometry (ESI-MS). The further research should also utilise some tools and techniques like cell culture, biotransformation, drug delivery, drug targeting among others. Other aspects which must be worked out are viability, competency, shelf life among others.

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