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Effect of *Ricinus communis L* on Microorganisms: Advantages and Disadvantages

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Castor is an important industrial and medicinal plant, as raw material for thousands of compounds can be obtained from it. Castor contains a number of toxic compounds in different parts of the plant, ricin being the most potent. Highest concentration of inhibitors is found in seeds. These compounds show antimicrobial activity against different pathogenic bacteria. So, these toxic compounds can be used to prepare drugs to treat many diseases worldwide. Antimicrobial effect of castor was also seen against soil microbial community which in turn affects soil health and fertility. However, there are many physical, chemical and biological methods which help in degradation of castor inhibitors.

Introduction

Castor (*Ricinus communis* L) is an important oilseed crop belonging to the family, Euphorbiaceae. It is grown worldwide because of commercial importance of its oil. It is cultivated mainly in arid and semi arid regions in different countries, of which India, China and Brazil are major ones. Most of the global demand of castor oil is met by India, being the world's largest producer of it. In India, the leading state in castor oil production is Gujarat, followed by Rajasthan and Andhra Pradesh (http://www.nmce.co.in/files/study/castor.pdf). Castor can be grown easily in non productive lands and provides viable income in all subtropical and tropical locations that require crops with low input costs (Gana *et al.*, 2014). It can prevent desertification and erosion in marginal lands if grown there. It is generally cultivated in semiarid regions where germination and plant growth may be affected by salinity stress(Berman and Wiesman, 2011). It contains optimum level of nutrients like nitrogen, phosphorous and potassium, so it can be used as source of fertilizers for different crops (http://www.nmce.co.in/files/study/castor.pdf). The use of castor oil in manufacturing surfactants, greases, coatings, cosmetics, pharmaceuticals and many other compounds shows its commercial relevance. Moreover, various extracts of roots, seeds and leaves posses antimicrobial activity, antidiabetic activity and anti-inflammatory activity (Jeyaseelan and Jashothan, 2012).

The castor contains many compounds that are poisonous to human beings, animals, insects and microorganisms. The major toxic protein, ricin is used as a biological weapon as a single milligram can kill an adult human being. It is mainly present in seeds (http://chemistry.about.com/cs/toxicchemicals/a/aa040403a.htm). Ricin inhibits protein synthesis by acting mainly on eukaryotic ribosomes. So, fungi are more susceptible to it than bacteria (Zartman *et al.,* 2003). In addition, the plant contains steroids, saponins, alkaloids, flavonoids, tannins, phenols, phytates, oxalates and glycosides in different parts of the plant including roots, leaves and seeds. All these compounds are responsible for antimicrobial properties of castor. Since, these toxic compounds are present in all parts of the plant so, antimicrobial properties are also shown by whole plant (Jena and Gupta, 2012).

Ricinus communis possess good antimicrobial activities against pathogenic bacterial strains such as *Staphylococcus aureus, Streptococcus progenies, Bacillus subtilis* as well as *Pseudomonas aeruginosa, Klebsiella pneumoniae, Proteus vulgaris, Salmonella typhimurium, Escherichia coli* and many others. Castor also shows antimicrobial activity against some fungal pathogens i.e. *Candida albicans, Aspergillus niger* etc (Islam *et al.,* 2010; Mathur *et al.,* 2011). However, in addition to human pathogens castor inhibitors also have negative effect on soil microbial community. Soil health and productivity is directly related to soil microflora as it is an intimate part of soil organic matter and supports growth and development of different crops in many ways. So, cultivation of castor not only decline microbial count but also affects soil fertility (Zartman *et al.,* 2003).

Advantages

Medicinal plants can be a good alternative to conventional medicines in combating diseases caused by infectious microorganisms. These plants contain a number of natural products which can be used to manufacture synthetic drugs. Numerous plants with medicinal properties have been gifted to mankind by nature. The interest in scientific research of *R. communis* is due to its efficacy in the alleviation of a number of diseases worldwide because of presence of toxic compounds in different parts of the plant (Mathur *et al.,* 2011). In the recent years, a number of researchers studied the antimicrobial properties of *R. communis* throughout the world.

Ferreira *et al.,* (2002) found that antimicrobial activity of castor oil plant detergent on different anaerobic bacteria (*Fusobacterium nucleatum* ATCC 25586, *Clostridium perfringens* ATCC 13124, *Prevotella nigrescens* ATCC 33563 and *Bacteroides fragilis* ATCC 25285) was different. Jombo *et al.,* (2008) reported that water and alcohol extracts of dry seeds and leaves of *R. communis* have significant antibacterial activity against *K. pneumonia, E. coli, P. vulgaris* and *S. aureus.* Antibacterial activity of various leaf extracts of castor was reported by Islam *et al.,* (2010) against dermatophytic and pathogenic bacteria such as *Staphylococcus aureus, Escherichia coli, K. pneumoniae* and *Streptococcus pyogenes*. These findings established the potential of the leaves of *Ricinus communis* as an effective antibacterial agent. Khan and Yadav (2011) evaluated cold and hot aqueous and different organic solvent extracts of leaves, stem and roots of castor for their antifungal properties against *Trychophyton rubrum, Candida* *albican* and *Microsporum* sp. They found that in case of leaves cold aqueous, metahnolic and acetone extracts were effective while in case of stem, only cold aqueous extracts were effective. Cold aqueous extracts of roots were most effective followed by acetone, ethyl acetate and hexane extracts.

Al-kuraishy *et al.,* (2012) reported that *Ricinnus communis* produces significant antimicrobial activity particularly against Gram negative bacteria, in comparison with standard antibiotics. They selected four bacterial genera - two Gram negative (*Escherichia coli* and *Pseudomonas aeruginosa*); and two Gram positive *(Staphylococcus aureus, Enterococcus fecalis*) and found that the minimum inhibitory concentration (MIC) of aqueous extracts ranged between 8-32 mg ml^{-1} for all. Iqbal *et al.,* (2012) studied the antibacterial activity of aerial parts of *R. communis* against two Gram-positive bacteria, namely *Staphylococcus aureus* and *Bacillus subtilis* and two Gram-negative bacteria, namely *Escherichia coli* and *Shigella flexneri.* Ethyl acetate and chloroform extracts were showing more effective MIC values against bacterial strains. The least active fraction among all the extracts was *n*-butanol showing 0.625 and 2.50 μg ml^{-1}, antibacterial activity against *S. aureus* and *S. flexneri*, respectively.

Jeyaseelan and Jashothan (2012) studied antibacterial activity of different leaf extracts of *Ricinus communis* L against pathogenic bacteria *Staphylococcus aureus* (NCTC 6571) and *Escherichia coli* (ATCC 25922). They found that all the four test extracts showed inhibition on both *S. aureus* and *E. coli* due to presence of inhibitory compounds like saponins, tannins, flavonoids, cardiac glycosides and terpenoids in all test extracts. Naz and Bano (2012) studied the antibacterial and antifungal activity of methanol, ethanol and aqueous leaf extracts of the plant *Ricinus communis*. Both Gram positive (*Bacillus subtilis*: ATCC 6059 and S*taphylococcus aureus:* ATCC 6538) and Gram negative bacteria (*Pseudomonas aeruginosa*: ATCC 7221 and *Klebsiella pneumoniae*) were found to be more sensitive to methanolic leaf extracts. Methanolic and aqueous leaf extracts also showed antifungal activity against selected fungal strains as *Aspergillus fumigatus* and *Aspergillus flavus.*

Momoh *et al.,* (2012) studied the antimicrobial activity of the essential oil of castor (*Ricinus communis*) seeds extracted using soxhlet extractor in 98% n - hexane against fourteen bacteria and six fungi. Comparatively, fungi were found to be less susceptible than bacteria. Poonam and Pratap (2012) studied the antimicrobial activity of seed extracts of castor against some human pathogenic bacteria namely *Bacillus subtilis, Bacillus cereus,* S*taphylococcus aureus, Escherichia coli* and two fungal strains namely *Candida albicans* and *Candida glabrata*. Bhaumik *et al.,* (2014) screened the *in vitro* antimicrobial activity of various extracts of fruit-seeds of *R. communis* using bacterial cultures *Staphylococcus aureus* (ATCC 9144), *Bacillus subtilis* (ATCC 6633), *Pseudomonas aeruginosa* (ATCC 27853) *Escherichia coli* (ATCC 25922) and fungal cultures *Aspergillus niger* (ATCC 9029), *Aspergillus flavus* (ATCC 204304), *Candida albicans* (ATCC 10231).

They found that most of the extracts executed moderate to good antimicrobial activity against all the tested micro-organisms. Javaid *et al.,* (2015) screened antimicrobial activity of various seeds extracts of castor against *Rhodococcus spp, Escherichia coli, Bacillus subtilis, Aspergillus flavus, Aspergillus niger* and *Trichoderma harzianum.* Chloroform and Methanol extracts showed maximum zone of inhibition against bacterial and fungal strains, while Acetone extracts showed significant antifungal activity than antibacterial activity.

Disadvantages

Soil microflora is one of the most important factors which enhance soil fertility in many ways. Microbes are the only source in soil which covert nutrients into forms that can be utilized by the plants and play important role in nutrient cycling (Gaddeyya, 2012). Microbes can be used as biofertilizers in concern with the negative aspect of chemical fertilizers. Biofertilizers promote vegetative growth and yield of crops by providing required nutrients viz. nitrogen, phosphorus, iron, zinc, copper, etc. Moreover, they produce plant growth promoting hormones, vitamins and amino acids and control plant pathogens, thus increase crop production and help in the improvement of soil health (Glick, 1995; Saharan and Nehra, 2011; Mishra *et al.*, 2013). Kumar and Kanjana (2009) concluded that the application of specific bacterial strains can enhance nutrients availability by accelerating the mineralization processes of organic matter in soil, which in turn encourages the vegetative growth and yields of castor. Moreover, many researchers reported that using bio-fertilizers in addition to organic fertilizer led to improvement of vegetative growth and productivity of castor (Patel *et al.*, 2010). Application of biofertilizers to castor can achieve the merits including increasing the soil fertility, saving N-fertilizers, increasing the availability of various nutrients to plant absorption and led to improvement of plant growth and yield (Hussein *et al.*, 2013; Aruna *et al.*, 2015).

As discussed, castor possessed antimicrobial properties due to presence of different toxic compounds. In addition to human pathogens castor inhibitors also affect fungal and bacterial functional diversity in soils after bean maturation. Fungal diversity declined in soils cultivated with castor as compared to fields cultivated with cotton (Zartman *et al.*, 2003). A significant decline in the population of *Bradyrhizobium* sp. was observed when castor was cultivated in preceding year. This might indicate sensitivity of certain fungal and bacterial species to residual inhibitors in the soil which, in turn, affects soil health and growth of plants (Venkateswarlu *et al.*, 1997). However, there are certain microorganisms which can survive at high concentrations of inhibitors and can effectively degrade them. *Actinomycetes* concentrations as high as 30,000/g of soil identified in castor field soils might decompose ricin. Though, *in vitro* assays indicate that this group of bacteria is not effective at degrading ricin. On the other hand, two other bacterial genera, *Pseudomonas* and *Erwinia* can effectively degrade the protein in *in vitro* assay. So these bacteria may be used as biofertilizers for castor so that soil health can be retained in castor grown fields in addition to promoting plant growth and yield (Zartman *et al.*, 2003).*Streptomyces thermophilus*, *Str. Diacetilactis* and *Lactobacillus acidophilus* are also used for the detoxifation of castor cake in *in vitro* assays (Ulanova and Kravchenko, 2013). Many physical, chemical and biological methods are used for the detoxification of casor toxins. Ricin can be detoxified by treatment with proteolytic enzymes, autolysed yeast or *Azotobacter*, sodium ricinoleate, H_2O_2, $KMnO_4$, halogens, ethanol extraction, heat and UV irradiation. Another important toxin ricinine can be inactivated by steam treatment, or by heat treatment with lime, $Ca(OH)_2$, NaCl, formaldehyde, NH_4OH, $(NH_4)_2SO_4$, $KMnO_4$ or urea (Rao, 1970).

Fungal and bacterial functional diversity declined in soils after bean maturation. Fungal taxonomic diversity declined in soils cultivated with castor relative to fields cultivated with cotton. This might indicate sensitivity of certain fungal species to residual ricin in the soil. Fungi being eukaryotic are expected to be susceptible to ricin. Bacteria, which have a different ribosome structure from eukaryotes are resistant to ricin and therefore any observed changes in populations, cannot be directly ascribed to ricin levels. However, since bacteria may be dependent on fungi for degradation of certain components of soil organic matter, fluctuations in bacterial numbers might reflect fluctuations in fungal populations. Actinomycete concentration as high as 30,000/g of soil identified in castor field soils might effectively decompose ricin. In vitro assays indicate that this group of bacteria was not effective at degrading ricin. On the other hand, two other bacteria genera, Pseudomonas and Erwinia were observed to effectively degrade the protein in in vitro assays. Fungal and bacterial functional diversity declined in soils after bean maturation. Fungal taxonomic diversity declined in soils cultivated with castor relative to fields cultivated with cotton. This might indicate sensitivity of certain fungal species to residual ricin in the soil. Fungi being eukaryotic are expected to be susceptible to ricin. Bacteria, which have a different ribosome structure from eukaryotes are resistant to ricin and therefore any observed changes in populations, cannot be directly ascribed to ricin levels. However, since bacteria may be dependent on fungi for degradation of certain components of soil organic matter, fluctuations in bacterial numbers might reflect fluctuations in fungal populations. Actinomycete concentration as high as 30,000/g of soil identified in castor field soils might effectively decompose ricin. In vitro assays indicate that this group of bacteria was not effective at degrading ricin. On the other hand, two other bacteria genera, Pseudomonas and Erwinia were observed to effectively degrade the protein in in vitro assays. Fungal and bacterial functional diversity declined in soils after bean maturation. Fungal taxonomic diversity declined in soils cultivated with castor relative to fields cultivated with cotton. This might indicate sensitivity of certain fungal species to residual ricin in the soil. Fungi being eukaryotic are expected to be susceptible to ricin. Bacteria, which have a different ribosome structure from eukaryotes are resistant to ricin and therefore any observed changes in populations, cannot be directly ascribed to ricin levels. However, since bacteria may be dependent on fungi for degradation of certain components of soil organic matter, fluctuations in bacterial numbers might reflect fluctuations in fungal populations. Actinomycete concentration as high as 30,000/g of soil identified in castor field soils might effectively decompose ricin. In vitro assays indicate that this group of bacteria was not effective at degrading ricin. On the other hand, two other bacteria genera, Pseudomonas and Erwinia were observed to effectively degrade the protein in in vitro assays.

In conclusion, castor possesses good antimicrobial activity against many pathogenic microorganisms due to presence of a number of different inhibitory compounds. Therefore, various extracts of castor can be used to manufacture drugs which may be used to treat a number of diseases instead of conventional antibiotics. Moreover, negative effect of castor on soil microorganisms and soil health can also be minimized if resistant strains of bacteria are used as biofertilizers in castor grown fields.

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