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Review Article

Physiological and Pharmaceutical Effects of Tribulus Terrestris as a Multipurpose and Valuable Medicinal Plant

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ABSTRACT

Tribulus terrestris is a herbal remedy which is used for various purposes in folk medicine. It has been used as tonic, aphrodisiac, astringent, analgesic, stomachic, anti-hypertensive, diuretic and urinary anti-septic. It is about 30 to 70cm high; it grows as a summer annual, has pinnately compound leaves, yellow flowers and stellate shaped carpel fruits. Since the past decades, some plants have been playing important role in disease curing along with artificial medications commonly called medicinal plants. Some have compared the tonic properties of Tribulus terrestris to the effects of ginseng, but these occur due to entirely different mechanisms. It is also claimed that Tribulus terrestris increases testosterone by increasing gonadotropin releasing hormone (GnRH) which in turn stimulates the production of LH and follicle stimulating hormone (FSH). Testosterone, besides its role in muscle-building and raising fertility and libido, is also known to have a positive effect on bone marrow activity (for red blood cell production) and the immune system.

Introduction

According to the World Health Organization about 80% of the world's population living in developing countries relies essentially on plants for primary health care [19]. Herbal medicine associated pharmacology and pharmaceutical products are updated frequently [34]. At present time, it is easier to determine efficacy and safety of herbal remedies, because it is known which chemical compounds are present in these plants and which of these compounds are associated with a number of side effects [28]. Extensive use of antibiotics results in residual medication of poultry products as well as bacterial antibiotic resistance and tolerance. This situation represents a considerable risk to human health [18]. The banning of the use of nutritive antibiotics has accelerated and led to investigations of alternative feed additives in poultry production [24]. Plant extracts can play a role in supporting both performance and health status of the poultry. Beneficial effect of herbal extract or active substances in poultry nutrition may include the stimulation of appetite and feed intake, the improvement of endogenous digestive enzyme secretion, activation of immune response and antibacterial antiviral antioxidant and antihelminthic actions. They are also seen to have a great potential in practical application. One of the most popular phytoproducts is the extract of the flowering

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annual herb Tribulus terrestris Linn. (Zygophilaceae). This extract is harmless for humans and animals and contains biologically active substances as saponins, flavonoids, [30, 33], glycosides, phytosterols [37], alkaloids and other constituents [38]. Its main active components are saponins of the furostanol type, termed protodioscin [17]. Flavonoids have anti-inflammatory effect and improve the overall physiological status of the animals. Tannins influence gastrointestinal microflora and exert astringent effect due to their antibacterial properties [32]. Our earlier investigations have shown that dry extract of Tribulus terrestris increase significantly calcium level in the blood serum in broilers parent [11]; decrease significantly glucose blood level in laying hens [11]; decline total serum cholesterol in laying hens and broiler parents [11]. This changes are related with increased growth rate and egg performance. On the other hand it is well known that growth performance is closely related with poultry health status. There are no data concerning the effect of Tribulus terrestris extract on blood biochemical parameters in other poultry species. The plant under study is a Tribulus terrestris. Tribulus terrestris more often has the smaller flowers that are brighter yellow (versus yellow-orange), although variability within each species and taxa often makes these generalities deficient for proper identification. Also, there are some general and subtle differences in the leaves (leaflet number, shape, and hairiness), and getting to know each plant well seems to be the best remedy for proper in-the-field identification. Below are descriptions of the taxa; see glossary above for definitions of terminology.

Biology

Tribulus terrestris is a C4, summer annual, reproducing by seed; it is prostrate and mat-forming. Tribulus terrestris plant material from California was found to be diploid; 2n=24 [14]. Generally, Tribulus terrestris has a considerable seed dormancy lasting over fall and winter months [35] with some seeds staying dormant for longer periods of time. Its seedlings emerge in the early spring through summer, often in flushes following increased soil moisture [5]. It germinates after the start of the monsoon rains, on any type of barren soil, in southern Arizona [21]. In Washington and Australia, it germinates in the late spring to early summer, when necessary soil moisture conditions are met [30, 35]. It is a prostrate mat-forming plant with trailing stems, although can be more ascending when light competition exists on a site [15, 39]. Seedlings develop a deep root system in a few weeks; flowers may be produced within 3 weeks, fruits/burrs within 6 weeks [5, 35]. Tribulus terrestris roots can develop nitrogen-fixing nodules [2, 5]. Athar and Mahmood [2] observed that plants having root nodules had more lush green healthy growth and greater dry weight versus stunted growth in plants without nodules. Boydston [3] reports that flowering occurred within 3-4 weeks of emergence when temperatures were consistently above 68° F (20°C), regardless of planting date. Tribulus terrestris flowers March through October in Arizona, although primarily from July to August [21]. Once the plant begins to flower, it is continuous throughout the plant's life [25]. Tribulus terrestris flowers are crosspollinated by insects (foragers include: Coleoptera, Diptera, Hymenoptera, Lepidoptera, Thysanoptera) [5, 35] along with being self-pollinated, which occurs at the end of each flower's receptive period (within one day) [25]. Self-pollination is accomplished when the petals begin to close and push the stamen inward toward the stigma, the longer anthers making direct contact; the potential of this system is 100% seed set [25]. Fruits mature in approximately 2 weeks, and subsequently split apart into segments soon afterward [15]. Plants continue to reproduce and produce fruit until the cool season begins. Boydston [3] reports during trials in Washington, fruit/burr production stopped in October when average temperatures were under 68°F (20°C)

Seed production

Tribulus terrestris plants typically bear numerous fruits/schizocarps/burrs (averaging 200-5000 per plant) [5]. Boydston [3] reports that seeds planted in May, June, July, and August subsequently produced 5600, 5200, 3600, and 200 burrs/plant, respectively. Although, fruit/burr production seemingly responds to temperatures during a season's growth, enabling greater production for a longer period of time in warmer years [3]. Each fruit/burr usually contains 5 nutlets (cocci), each nutlet (coccus) can contain 2-5 seeds [3].

Seed dispersal

Each fruit section (coccus) has 2 sharp divergent spines and several other spines and warty protuberances enabling the Tribulus terrestris fruits to easily attach to animals and humans and to stick onto vehicle tires (cars, farm, airplane), subsequently facilitating long distance dispersion and spread [7, 27, 29, 36]. Holm et al. [15] points out that due to the architecture of the schizocarp/fruit, the large and small spines are arranged at different angles with at least one of the spines always pointing upward no matter how the fruits/burrs fall from the plant, and can easily imbed into feet, hooves, or tires. After getting caught or imbedded into the hooves, feet, and wool of livestock and other animals, the fruits/burrs are subsequently broken off as the animals try to rid themselves of the irritation [27]. Furthermore, they can stick to the shoes and clothing of people, and the fur and feathers of animals [5]. Tribulus terrestris fruits/burrs are also a contaminate of seed, feed, and wool of livestock [16, 9]. Foy et al. [8] report that Tribulus terrestris "presumably" was unintentionally imported into the United States on the tires of military planes returning from the Sahara Desert region; and has been further spread on this continent on the tires of aircraft and cars.

Ecology

Tribulus terrestris is native to southern Europe [12, 21], Africa, temperate and tropical Asia (Afghanistan, Armenia, Azerbaijan, China, Cyprus Sinai, Georgia, Iran, Iraq, Israel, Japan, Jordan, Kazakhstan, Kyrgyzstan, Lebanon, Mongolia, Russian Federation (Ciscaucasia, southeast Western Siberia), Saudi Arabia, Syria, Tajikistan, Turkey, Turkmenistan, Uzbekistan, India, Pakistan), and north Australia [12]; it was introduced here from the Mediterranean [5]. Squires [29] comments that Tribulus terrestris probably originated in the Saharan region, and spread into the Mediterranean region. Tribulus terrestris was accidentally imported from the Mediterranean into the United States on livestock [1, 9, 35]. It was first reported in California in 1903 [6, 29].

Germination

Most newly matured Tribulus terrestris seeds are dormant and require an afterripening period of approximately 6-12 months. Ernst and Tolsma [7] report that dormancy of seeds was very high in both fresh seeds and 3-6 year old seeds. Squires [29] reports that freshly harvested seeds have a germination rate of 10%, and dry-stored 6-month-old seeds have a germination rate of 84%. Imbibition of water differed in dormant versus non-dormant seeds: measurements taken at one hour and periodically through one day of imbibition showed dormant seeds had approximately half of the water content of non-dormant seeds [7]. The largest seed within a nutlet (coccus) is usually the first to germinate; the remaining seeds may germinate or remain dormant depending on moisture availability [5]; this large seed is usually positioned near the basal end of the burr (coccus) [31]. Pathak [22] reports that Tribulus terrestris germination is inhibited by low temperatures, low light intensities, and wet soil. The optimum temperature range for germination to occur is 81-95°F (27-35°C). In Australia, germination occurs when the maximum air temperature is approximately 75-81°F (24-27°C) [29]. During trials, Tribulus terrestris emergence was initiated when average soil temperatures reached 59°F (15°C) for at least 2 weeks and approached 68° F (20°C) [3]. After initial emergence occurred, emergence was multipeaked with no relationship existing with temperature for the remainder of the summer [3]. In subsequent years, emergence occurred and peaked at similar times regardless of the age of the seed, indicating environmental stimuli influencing emergence [3]. Tribulus terrestris seedlings emerge during early spring through summer, often in flushes following increased soil moisture [5, 20, 15]. During field observations in Botswana, Tribulus terrestris was observed to germinate and emerge following a rainshower having more than 0.04 in. (10 mm) of precipitation [7]. Maximum germination occurred after a series of heavy rains, facilitating a 35% germination rate, with continued germination of seeds lasting for another 4 months [7]. On sandy soils, seedlings emerge from depths to approximately 5 cm (less on heavy soils) [5]. Squires [29] reports that seeds buried more than 4 in. (10 cm) deep in sandy soils, can successfully emerge. Germination was irregular in Tribulus terrestris seeds, whether seeds remained in the fruit (cocci) or were isolated [7]. In greenhouse trials, the highest germination rate was achieved by isolated seeds with a maximum of 66.9%, and a mean of 37.3±25.1% (ranging from 68/59°F (20/15°C) up to 95/86°F (35/30°C), in 5°C increments, alternating day/night temperatures). Seeds that remained in the fruits rarely germinated synchronously [7]. Ernst and Tolsma [7] add that because of this pattern, direct competition for water and nutrients is avoided.

Conclusion

Tribulus terrestris is a flowering plant in the family Zygophyllaceae, native to warm temperate and tropical regions of the Old World in southern Europe, southern Asia, throughout Africa, and in northern Australia. It is a taprooted herbaceous perennial plant that grows as a summer annual in colder climates. The stems radiate from the crown to a diameter of about 10 cm to over 1 m, often branching. They are usually prostrate, forming flat patches, though they may grow more upwards in shade or among taller plants. Some have compared the tonic properties of Tribulus terrestris to the effects of ginseng, but these occur due to entirely different mechanisms. Claims have been made that it enhances testosterone levels by increasing luteinizing hormone levels. LH is responsible for telling the body to produce testosterone. One interesting fact is that extended use of anabolic steroids reduces levels of LH, thus reducing and sometimes shutting down the body's production of testosterone.

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