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PRUSSIC ACID CONTENT IN SOME CROP PLANTS WITH REFERENCE TO ITS TOXICITY TO GRAZING ANIMALS

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Abstract: Production of prussic acid is the defense mechanism of plants against microbes and herbivores. Prussic acid or Hydrogen Cyanide (HCN) is known to occur in some 2,700 plants in the global flora. It is produced after enzymatic hydrolysis. The grazing animals when they consume the cyanogenic plants in large quantities, they suffer from the cyanide poisoning. The symptoms of poisoning are anxiety, progressive weakness and labored breathing, followed by death. In the present study, the author estimated the prussic acid content in some important crop plants of Marathwada region in the state of Maharashtra, India. The semi-quantitative estimation was done with the help of a simple kit. The study is crucial to recognize toxicity of crop plants.

Keywords: Crop plants, Cyanogenesis, Cyanogenic glycosides, Maharashtra, Prussic acid.

INTRODUCTION

Cyanide C≡N exists in various forms in nature as salts of sodium, potassium and calcium. The hydrocyanic acid (HCN) or better known as prussic acid is produced by number of plants of the World flora. At least 2,700 species of higher plants have been shown to contain one to nearly thirty-two compounds capable of producing prussic acid from amino acids (Seigler, 1976; Moller and Seigler, 1999; Jones, 1998). Cyanogenesis is a bio-chemical defense mechanism in plants to protect themselves from microbes as well as from herbivores. Amygdalin, Dhurrin, Prunasin, Linamarin, Lotaustaralin, Cardoispermin etc. are the cyanogenic glycosides present in cyanogenic plants (Eyjolfsson, 1970; Saunders and Conn, 1978). After hydrolysis, these glycosides release hydrogen cyanide. In the first step, with the help β-glycosidase enzyme, the cyanogenic glycoside present in some of the plants can be converted into sugar and an algycone. In the next step, this algycone is changed to aldehyde or ketone along with release of hydrocyanic acid.

$$\text{Cyanogenic glycosides} \xrightarrow{\beta\text{-Glycosidase}} \text{Sugar} + \text{Algycone}$$

$$\text{Algycone} \xrightarrow{\text{Hydroxynitrile lyase}} \text{Aldehyde or ketone} + \text{HCN}$$

Pathway of conversion of Cyanogenic Glycoside into HCN

Poisoning of prussic acid can be dangerous to the animals that eat cyanogenic plants but also to the plants themselves. In order to prevent this self-poisoning, the plants store cyanogenic glycosides in a vacuole of the cell and the enzymes that produce hydrogen cyanide in a separate compartment. When a cell is damaged the compartment walls are broken, the reaction takes place and hydrocyanic acid is produced. This damage can be done also due to herbivores. So HCN released due to mechanical damage kills the livestock.

Several plants, important from agriculture and horticulture point of view, are known to contain quite a good amount of hydrocyanic acid. Some of the crop plants which are very commonly cultivated in the Marathwada region of Maharashtra state are *Sorghum vulgare, Linum usitatissium, Carthamus tinctorius, Gossypium herbaceum, Triticum aestivum, Zea mays etc.* These crop plants are used by humans in various ways such as food, fodder etc.

The livestock when they consume the cyanogenic plants in large quantities, they suffer from cyanide poisoning. The symptoms of prussic acid poisoning include anxiety, progressive weakness and labored breathing, followed by death when a lethal amount of HCN is consumed. The ruminant animals like cattle, sheep and goats appear to be more susceptible to prussic acid poisoning. The toxic effect of HCN is almost quick *i.e.* as soon as it is liberated from the glycosides, its action commences. The specific action of prussic acid on livestock is that it combines with haemoglobin to form cyanoglobin which does not carry oxygen thus; the animal tissues are without oxygen and suffer from hypoxia. Some plant products like tannins (Goldstein and Spencer, 1985) and fungicide borax (Lebeau and Atkinson, 1967) also inhibit the process of cyanogenesis but the process of cyanogenesis can be inhibited by number of internal and external factors also.

The cyanide-poisoned animals show an increased rate of respiration, increased pulse rate, gasping, muscular twitching or nervousness, trembling, foam from the mouth, blue colouration of the lining of the mouth and spasms or convulsions and finally death occurs due to respiratory paralysis. Often blood passes from the nostrils and mouth.

In the Marathwada region of Maharashtra, Sorghum species and its hybrids are cultivated on large scale and a number of cattle die every year due to the consumption of tillers of Sorghum (Modgil *et al.*, 2006). In the present exploration, author attempted to study the cyanogenic crop plants to estimate the amount of HCN semi-quantitatively with special context to grazing animals.

MATERIALS AND METHOD

For experiment, important crop plants were collected from field in different seasons and tested for presence of cyanogen compound level in their leaf, fruit and seed extract by simple sodium picrate paper test. The leaf/fruit/seed extracts were taken in 0.2M phosphate buffer at pH 7 and centrifuged at 2000 rmp. The supernatant liquid was placed in a test tube.

The strip of Whatman filter paper no. 1, (5cm x 2cm in size) was soaked in sodium picrate solution and dried, and was hanged in the test tube containing the extract. The color of the picrate paper was observed, if the color changed from yellow to reddish brown, it confirmed the presence of prussic acid in the preparation and the test is positive. If the test is negative, the tube should be left at room temperature for further 24-48 hours and then re-examined for any non-enzymatic release of hydrocyanic acid. For quantitative estimation, the simple semi-quantitative method as described by Bradbury *et al.* (1999) was used (fig. 1).

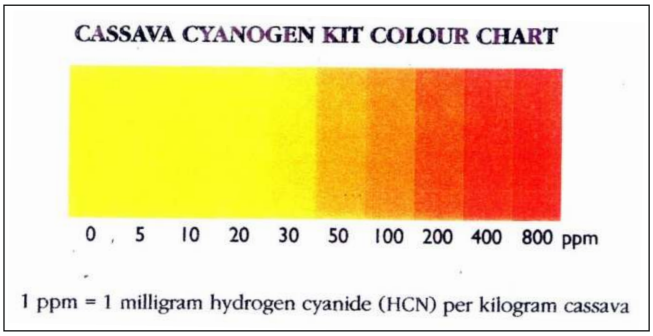

Fig. 1: Cassava cyanogen kit colour chart.

RESULTS AND DISCUSSION

The amount of prussic acid in eleven plants of Marathwada region of Maharashtra (India) were varied from 10-800. The maximum HCN level

Table 1: Detection and quantitative estimation of prussic acid in some important crop plants.

S. No.	Name of plants	Family	Tested plant part	Test result	Amount of HCN in ppm
1.	*Arachis hypogaea* L.	Fabaceae	Leaf	+ve	10
2.	*Carthamus tinctorius* L	Asteraceae	Leaf	+ve	20
3.	*Curcuma longa* L.	Zingiberaceae	Leaf Tuber	+ve +ve	20 20
4.	*Gossypium herbaceum* L.	Malvaceae	Leaf Bud	+ve +ve	20 20
5.	*Glycine max* (L.) Merr	Fabaceae	Leaf	-ve	00
6.	*Linum usitatissimum* L.	Linaceae	Leaf Root	+ve +ve	50 400
7.	*Ricinus communis* L.	Euphorbiaceae	Leaf, Fruit	+ve +ve	20 20
8.	*Sorghum vulgare* Pers.	Poaceae	Leaf Root	+ve +ve	800 100
9.	*Saccharum officinarum* L.	Poaceae	Leaf	+ve	20
10.	*Triticum aestivum* L.	Poaceae	Leaf	+ve	10
11.	*Zea mays* L.	Poaceae	Leaf	+ve	20

was found in *Sorghum vulgare,* moderate in *Linum usitatissimum* and minimum in *Arachis hypogaea* as well as in *Triticum aestivum* (Table 1). Thus, livestock generally left unwarranted in the field having *Sorghum vulgare* and *Linum usitatissimum* may suffer from poisoning. Farmers don't have immediate access to save the life of livestock but they often use antidote like compound, tannins etc. present in the form of leaf extract to treat the prussic acid poisoning.

Agricultural scientists are advised to develop genetically modified species of *Sorghum vulgare* and *Linum usitatissimum* that have the least amount of prussic acid in their leaves and seed extracts. Awareness campaign is highly recommended among farmers to develop the understanding about the matters concerned.

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