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"EFFECT OF PLANT NUTRITION IN INSECT, DEVELOPMENT AND PEST MANAGEMENT : A REVIEW"

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ABSTRACT

The insects possess a close and subtle relationship with their host plants. The growth, incidence, behaviour, physiology, ecology and other aspects of an insect life are in one way or another are correlated within the context of nutrition. Nutrition concerns the chemicals required by organism for its growth, tissue maintenance, reproduction and necessary to maintain these functions. It may determine resistance or susceptibility to pests. Among several plant nutrients, only 17 are essential for proper growth and development of plants and each nutrient plays important role in their growth. These nutrients are required by insects for their growth, tissue maintenance, reproduction and energy. They fulfill their requirements through feeding on plants. Nitrogen has positive effects on individual insect performance, probably due to deposition-induced improvements in host plant chemistry. These improvements include increased nitrogen and decreased carbon-based defensive compound concentrations. Potassium provides high resistance against insect–pests. High levels of potassium enhance secondary compound metabolism, reduce carbohydrate accumulation and plant damage from insect pests. Phosphorus also decreases the host suitability to various insect-pests.

KEYWORDS: *Plant Nutrition, Insect, Management and Development.*

INTRODUCTION

Plants provide food and shelter to majority of insects (Mello and Filho, 2002). Insects feeding on plants are herbivores (Douglas, 1993; Fraser and Grime, 1997; Carson and Root, 2000). Growth of plants as well as insects is interdependent in many ways (Panda and Khush, 1995). Development of plants depends on nutrient availability while that of insects depends on the quality of food available from its host plants (McGuinness, 1987; Gogi *et al*., 2012). The insect-plant relationship may be affected by the application of micro/ macro-nutrients to crop plants (Abro *et al*., 2004) as nutrient deficient plants are weak and vulnerable to incidences of plant disease and insect pest attack (Marschner, 1995; Huber and Thompson, 2007).

Nutrient management improves plant health, which enables the plant to tolerate the incidence of herbivores - sucking as well as chewing insect-pests (Gogi *et al*., 2012). The agricultural production continues to be constrained by a variety of biotic (e.g., pathogens, insects and weeds) and abiotic (e.g., drought, salinity, cold, frost and water- logging) factors that can significantly reduce the quantity and quality of crop production(Wang *et al*., 2013).

Terrestrial eukaryotic biodiversity is dominated by plants and the animals that eat them, the majority of which are insects (Simpson *et al.* 2015). Insect-pests are threat to agricultural productivity. They affect the crop yield, quality and aesthetic value. Nutritional quality of plant tissue is one of the main characteristics of host plant selection by phytophagous insects (Bernays and Chapman 1994). It has a substantial impact on the predisposition of plants to insect-pests. Unlike in human nutrition where the effect of nutrition on "health" has gained considerable importance, the implementation of "healthy" nutrition to improve resistance and tolerance of plants lags its potential.

Plant nutrition is a study that deals with plants' need for certain chemical elements including their specific and interactive effects on all aspects of plant growth and development, their availability, absorption, transport, and utilization. These chemical elements are referred to as plant nutrients. A plant nutrient is a chemical element that is essential for plant growth and reproduction. Essential element is a term often used to identify a plant nutrient. Plant nutrients can be classified on the basis of mineral composition, nutrients concentration and on the basis of their physiological functions. Besides carbon, hydrogen and oxygen, which plants obtain from carbon dioxide and water, 14 nutrients are recognized as essential viz., primary macronutrients (nitrogen, phosphorus and potassium), secondary macronutrients (calcium, magnesium and sulphur) and micronutrients (iron, manganese, zinc, copper, boron, molybdenum, chlorine and nickel) for growth of plants. The relative availability of various nutrients affects the growth and fitness of herbivores, whose biomass generally contains much greater concentrations of elements as compared to plants (Boswell *et al.* 2008). Qualitative nutritional requirements of insects include carbohydrates, proteins, amino acids, fatty acids, minerals and vitamins. Insects get their nutrients from plants through feeding. Insect Nutrition is the science that interprets the interaction of nutrients and other substances in food in relation to maintenance, growth, reproduction, health and disease of an organism. It includes food intake, absorption, assimilation, biosynthesis, catabolism and excretion.

Discussion:

Nitrogen and phloem feeders:

Nitrogen is one of the most important factors influencing the performance of herbivorous insects (Douglas, 1993). Nitrogen has been found to affect the reproduction, longevity and overall fitness of certain pests (Jahn, 2004). Synthetic fertilizer application, especially Nitrogen fertilizer resulted in the more serious insect herbivores occurrence and crop damage from these insects by reducing plant resistance (Bi *et al*., 2001; Ge *et al*., 2003). Bhinde (1993) reported that low Nitrogen contents in the plants enhance the resistance of plants against pests, but high Nitrogen contents cause vigorous growth along with consequent decrease in resistance against pests. Ahmed *et al*., (2007) found that the highest rates of Nitrogen resulted in the highest per leaf mean population of jassid, whitefly and thrips.

The plant nutritional quality and defense mechanism against herbivores are altered by Nitrogen fertilization (Chen *et al*., 2008) as it may affect incidences of pests and their natural enemies (Chen and Ruberson, 2008). Cisneros and Godfery (1998) reported that Nitrogen affected the population dynamics of naturally occurring aphids with higher densities in plots receiving high Nitrogen rates. High levels of Nitrogen fertilization also appear to promote increased cotton aphid reproduction and the build-up of high in-field aphid populations (Godfery *et al*., 1999).

Bi *et al*., (2003) in another study observed a positive response between Nitrogen application rates and the numbers of adult and immature whiteflies appearing during population peaks. Kumar *et al*., (1998) concluded that mustard aphid infestation increased with increasing level of Nitrogen. According to Singh *et al*., (1995) an increase in the level of Nitrogen application resulted in an increase in the infestation of *Lipaphis erysimi* on musturd. Ebert (1996) reported that Nitrogen is taken up by plants in two different forms, nitrate or ammonium. The amino acid compositions were different among plants with different Nitrogen treatments, and amino acid content and carbohydrate-to-amino acid ratios were linked to changes in aphid development.

Coulibaly (1990) reported that the increasing application of Nitrogen fertilizer reduced the fibre content in sugarcane and resulted in increased damage by the stem borer. Lu *et al*., (2007) reported that Nitrogen is one of the most important factors in development of herbivore populations. The application of Nitrogen fertilizer in plants can normally increase herbivore feeding preference, food consumption, survival, growth, reproduction, and population density. Prudic *et al*., (2005) reported that plant nutritional quality and plant defenses that directly act on herbivores are altered by Nitrogen fertilization and herbivorous insects can distinguish between plants receiving different Nitrogen applications.

Van Emden (1966) found that in 41 percent of studies he reviewed aphids responded positively to Nitrogen fertilization, in 36 percent they responded negatively and in 23 percent, there was no response. In a more recent review, Waring and Cobb (1992) showed that in approximately 55 percent of the studies the response of sucking pests was positive due to Nitrogen fertilization and in 25 per cent there was no response. Scriber (1984) while reviewing 50 years of research relating to crop nutrition and insect attack found 135 studies showing increased damage and/or growth of leaf-chewing insects or mites in Nitrogen fertilized crops, versus fewer than 50 studies in which herbivore damage was reduced by normal fertilization regimens.

Phosphorous and Phloem Feeders:

Skinner and Cohen (1994) reported that higher Phosphorous levels are associated with higher insect levels. Jansson and Ekbom (2002) found that as Phosphorous fertilizer levels increased, the development time of aphid (*Macrosiphum euphorbiae*) shortened while the lifespan of adult and its number of offspring increased. Even though recent reports showed that, the application of Phosphorus reduced the population densities and damage of pod sucking bugs (Pitan *et al*., 2000) and *Empoasca dolichi* Paoli (Shri Ram *et al.*, 1987, 1990), not much is known of its effects on other insect pests. Waring and Cobb (1992) concluded that Phosphorous often does not influence sucking insects (about 48%) or influences them positively (approximately 38%).

Potassium and phloem feeders:

Potassium has been considered a key component of plant nutrition that significantly influences crop growth and some pests infestation. Amtmann *et al*., (2008) suggested that Potassium ion from soil supply may affect a number of physiological, metabolic and hormonal processes in plant tissues. These processes are likely to be crucial for plants susceptibility or resistance to pathogens and insects. Potassium fertilizer is negatively associated with occurrence of *Aphis glycines* (Myers and Gratton, 2006), leafhoppers and mites (Parihar and Upadhyay, 2001). Potassium nutrition has a profound effect on the profile and distribution of primary metabolites in plant tissues, which in turn could affect the attractiveness of plant for insects and pathogens as well as their subsequent growth and development (Amtmann *et al*., 2008).

Amtmann *et al*., (2008) provide a potential mechanism to explain the relationship between Potassium deficiency and increased insect attack. Potassium deficiency results in reduced synthesis of proteins, starch, and cellulose, and increased accumulation of lower molecular weight compounds such as amino acids, nitrate, soluble sugars, and organic acids. These lower weight molecular compounds are more easily utilized as nutrient sources by sucking insects. Thus in other words, Potassium deficiency on its own may not correlate with higher insect attack, but the subsequent impact of Potassium deficiency on plants, makes plants more readily attacked by sucking insects. This is better explained by (Walter and DiFonzo, 2007) who reported that low Potassium fertility was associated with high foliar levels of the amino acid serine and higher aphid infestations**.** Vaithillingan and Baskaran (1983) reported that increase Potassium level led to accumulation of more phenols which probably contributed to increase insect resistance in some rice cultivars (Baskaran *et al*., 1982). Moreover, Potassium induced changes in rice plant had profound effect on insect- host interactions.

Management through fertilizers:

The indirect effects of fertilization practices acting through changes in the nutrient composition of the crop have been reported to influence plant resistance to many insect pests. Excessive and/or inappropriate use of inorganic fertilizers can cause nutrient imbalances and lower pest resistance (Rashid *et al.* 2016). Proper fertilization is necessary to give the plants a certain level of resistance against pests. Primary pest defense of plants like physical and biochemical properties can be enhanced by balanced fertilization with plant nutrients. It is concluded that when soil amendments such as poultry manure and inorganic fertilizers are applied to restore or increase fertility, pest control measures such as the use of chemical insecticides and other pest management options should be put in place to mitigate the effects of infestation of insect pests on crop productivity. Rising levels of available nutrients have altered the global nutrient cycle substantially with consequential changes in terrestrial and aquatic systems (Aber *et al.* 2003).

Management through Phosphorus:

Phosphorus decreases the host suitability of potato plants against various insect-pests by changing secondary metaboiltes such as phenolics and terpenes and accumulation of phenolics (tannin, lignin) acts as barrier having deterring (antifeedent) or directly toxic(insecticidal) effects on herbivores (Facknath and Lalljee 2005). Phenolics interfere with digestion, slow growth, block enzyme activity and cell division. Terpenes like monoterpenes, sesquiterpenes, terpene polymers interefere with neural transmission, block phosphorylation and gum up insects. Excessive dietary P (1%) reduced growth and survival of some insects. Eg.- *Schistocerca Americana.*

Effect of potassium in different pest groups:

- Hemiptera
- Thysanoptera
- Lepidoptera
- Diptera
- Arachnida

Most indications (89%) concern five pest groups which are in order of importance Hemiptera, Lepidoptera, Arachnida, Coleoptera and Thysanoptera. The beneficial effect of potassium largely predominates in the case of plant hoppers and Coleoptera while for Lepidoptera and mites, numbers of indications of a depression or stimulation are similar. Potassium provides high resistance against insect–pests. High levels of potassium enhance secondary compound metabolism, reduce carbohydrate accumulation and plant damage from insect pests. A significant interaction between nitrogen and potassium levels was found in which the greatest increases of shoot and root dry matter with increasing N levels were found at the highest potassium level. High potassium application decreased population build up and dry weight of Brown plant hopper (Rashid *et al.* 2013). Incorporating potassium silicate into nutrient solutions did not confer resistance to pest populations developing on poinsettia leaves and applications of the silicon **f**ertilizer failed to enhance the plant growth against *Trialeurodes vaporariorum*. The percent surviving larvae, their body weight and population of sugarcane borer (*Chilo suppressalis*), rice leaf folder (*Cnaphalocrocis medinalis*) decreased due to high potassium application.

Management through potassium:

High dose of potassium decreases the nitrogen uptake. It adversely affects the biology and behavior of insects. Increase in potassium dose decreases intake and assimilation of food. Excessive amount of potassium causes quantitative changes in nutrients and allelochemicals. They strongly influence the chemical environment of the plant and play an important role in suppressing the population. High accumulation of potassium by crops during optimal growing conditions may be considered as an "insurance strategy" to enable the plant to better survive under sudden environmental stress.

Management through Nitrogen:

Less dose of Nitrogen increase the Chlorogenic acid which acts as a resistance factor in chrysanthemum plants e.g.- phenylpropanoids chlorogenic acid and feruloyl quinic acid present in higher amount in thrips-resistant chrysanthemums. Proper application of nitrogen fertilizers would be beneficial to manage insect herbivores such as cotton aphid. The optimal regime of nitrogen fertilizer in irrigated paddy fields is proposed to improve the nitrogen use efficiency and reduce the environmental pollution. Cotton aphid population density was significantly affected by interaction of nitrogen and potassium fertilizers in field experiments of two years, these results indicated that cotton aphid population density at seedling stage was suppressed by potassium fertilizer and the combination of potassium and nitrogen fertilizers in proper rate (K:N = 1:0.9 or 1:1.2 kg/ha). Suggesting that proper application of potassium and nitrogen fertilizers should be beneficial to controlling insect herbivores such as cotton aphid and plant growth at seedling stage of Bt-cotton field in Central China (Ai TC *et al.* 2011). Positive correlation between population growth rate of potato green peach aphid, *Myzus persicae* and concentrations of free amino acids in leaves of plants that received the nitrogen fertilization was rooted by (Jansson and Smilowitz 1986).

CONCLUSION:

Unlike in human nutrition where its effect on "health" has gained considerable importance, the implementation of "healthy" nutrition to improve resistance and tolerance of plants lags its potential. In modern agriculture, the most critical problem for increasing yield and developing sustainable agriculture is sufficient fertilizers supply and successful crop protection against herbivores. Herbivores are sensitive to alternation in host plant nutrition. Nutrient enrichment from agricultural and atmospheric sources has the potential to alter plant–insect interactions via changes in plant growth and defense. Optimized management of chemical fertilizers will be essential for achieving sustainability of intensive farming. If integrated crop production is to be extensively used in the future, a greater understanding of relationships among soil characteristics, fertilization practices, plant nutrient content and the ability of pests to reduce yield or crop quality will be required. The need for more healthful foods is stimulating the development of techniques to increase plant resistance to phytophagous insects.

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