Allelopathy of Moringa. A review

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ABSTRACT
The physical and chemical processes vital for growth and development of plants are frequently modified by chemicals released from neighboring plants. It is assumed that dominance of a certain crop plants in a field may be due to their strong allelopathic potential. Allelopathic crop water extracts combinations with lower rate of herbicides provide desired levels of weed control and in this way reduce herbicide usage. They can enhance the growth of plants when used in small concentrations. In achieving the potential yield, plant growth regulators PGRs play a vital role in modern agriculture. Plant growth regulators are the substances that influence the physiological processes and plant activity at low concentrations. PGRs are the compounds, natural or synthetic that are applied exogenously to a target plant to alter its life process or its structure to improve the quality and in order to enhance the yield of the crops. Thus plant growth regulators are organic substances which in low concentration promote, inhibit or modify growth and development, whereas growth inhibitors are organic compounds that retard growth generally. Hence, all the hormones are plant growth substances i.e. natural plant products but opposite are not true.

Introduction
Water is lifeline for all processes that are carried out in plants and even a slight deficiency results in yield losses and economically jeopardize the farmer’s investment. Various researches have demonstrated the fact even foliar application of water even in small amounts yields better results. Ozawa et al. (2006) conducted research to analyze the effects of mild and short dry spells on crop production. Foliar sprays were applied on the tomato, potato, cabbage, melon and papaya. It was found in the end that foliar water spray at 03:00 pm daily for nine days accelerated root growth in tomato, however, spraying at 9:00 pm and 12:00 pm did not significantly affected the yield. On the other hand foliar water spray in the late evening also accelerated papaya and sweet potato root growth but decelerated cabbage and melon root growth more and importance of foliar application of water came into light as a cheapest tool to increase the yield by supplementing water as a foliar spray for plant use. Another study in which Filipov et al. (1993) conducted field trials with foliar dressing using macro-and microelements along with water. It was found that on soils of strong water deficiency and low atmospheric moisture, the spray dressings on wheat did not increase the grain yield and protein content of wheat and proved to be useless but under conditions of high relative air humidity, fall of dew and adequate soil moisture, spraying of water as foliar spray was of positive effect. Under conditions of drought, wheat had no response to foliar application of microelements despite the fact that concentration of Fe, Mn, Cu, Zn and Co in soil was very low. This study indicated the fact that without adequate water availability, other nutrients failed to produce desired results, but in case of higher moisture contents and humidity all micronutrients yielded good response in a variety of crops.

Moringa Leaf Juice Allelopathy
Along with other plant requirements such as water macro and micro nutrients there are certain plant growth regulators and hormones that have the ability to increase the yield by influencing the plant internal processes. This fact was demonstrated in a detailed research in which Price (1985) reported that Juice from fresh Moringa leaves were used to produce a good and effective plant growth hormone, and reported that this hormone increased yields by 25-30% in a variety of crops including maize, onions, soya, sorghum, coffee and melon. It was later discovered that it was actually zeatin that is a natural plant
hormone and belongs to the cytokinine group, involved in increasing the yield of crops. It was suggested that zeatin foliar spray should be applied along with other fertilizers, making it clear that this hormone cannot serve in place of fertilizers but if applied along with other fertilizers produce better results. With this experiment, importance of moringa leaf juice as a natural plant growth promoter came into light. Same were the results presented by Fuglie (2000) that leaf extracts of M. oleifera accelerated growth of young plants, strengthened plants as a whole, improved plants resistance to pests and diseases, increased leaf area duration, increased number of roots, produced more and larger fruits and generally increased yield by 20 to 35%. He conducted field trials and applied the moringa leaf juice as a foliar spray and found that all the growth parameters were positively influenced by the spray and in the end it was observed that total yield was increased by 20%-35%.

This natural plant hormone has the potential to increase the yield of number of agronomic crops even when applied in small concentration. This fact was revealed by Foidle (2001) who reported that when foliar spray was applied on the leaves of plants with the Moringa leaf extract that was prepared in 80 % ethanol and then was diluted with water almost ten times produced some notable effects. It was reported in the end that this foliar spray of moringa water extracts enhanced the yield significantly despite the fact that it was applied in very in minute amounts. This research indicated that moringa leaf juice contain substances that promoted the vegetative growth and grain yield of many crops.

Seed and soil born diseases especially of fungal origin reduce the yield of crops and in some cases result in the complete destruction and failure of crops. Moringa leaf juice increased the yield of crops but Akinbode et al. (2008) even went a step ahead and explored the antifungal characteristics of moringa leaf juice. They applied in their research, moringa leaf extracts along with other plant extracts on seeds of cowpea and found that Moringa leaf extracts inhibited the attack of seed born fungal pathogens more significantly as compared to other plant water extracts. In this way antifungal characteristics of moringa leaf extracts came into light and open new horizons for moringa leaf use as an antifungal agent. After the determination of growth promoting properties of moringa leaf juice, next step was to determine the optimum concentration of moringa leaf juice. With this vision, Phiri (2010) applied Moringa oleifera leaf extracts in the ratio of 1:10 (w/v) on seeds of maize, sorghum and wheat in a growth room at 25°C for 14 days and found that it not only increased the length of radical but also increased hypocotyl length of maize and wheat. It was reported that this hormone application as a seed treatment not only improved the vegetative growth but also enhanced the grain yield even applied in very small amounts as a seed treatment. To verify the results of zeatin, Phiri (2010) conducted another series of experiments in which Moringa (Moringa oleifera) leaf extracts were applied on seeds of three legumes including beans, groundnut and cowpea and found that extract obtained from Moringa when applied in small concentration reduced time of germination. It was reported in the end that this moringa juica extracts also increased the length of hypocotyle of groundnut.

**Zeatin**

Zeatin obtained from moringa leaf juice is effective and yields positive results in a variety of crops. Makkar (1996) found that the juice from fresh Moringa leaves can be used to produce an effective plant growth hormone, increasing yields by 25%-30% for a number of crops such as soya, maize and coffee. Field trials were conducted on a number of agronomic crops and were sprayed with the juice extracted from the leaves of moringa. In the end it was found that moringa leaf juice increased the yield of the all the crops tested, by 25%-30%. After becoming aware of zeatin growth promoting character, scientists diverted their attention towards mineral composition of moringa leaves in order to discover that either any other type of hormone is promoting the growth of plants along with zeatin. Anjorin et al. (2010) studied the mineral composition of the lamina, petiole, seed pod and seed kernel oil of Moringa oleifera L. from two regions, Sheda and Kuje. Abuja, Nigeria in order to investigate the types of minerals and their composition. The results indicated that Ca, Mg, Fe and Cu in M. oleifera leaves, pods and seeds from Sheda were relatively higher than that from Kuje. Relatively high contents of calcium and iron were found in the lamina and seed shell of the plant respectively from both regions. The Mg content in the seed kernel oil of moringa from Sheda was significantly lower. It was also discovers that phosphorous was less than or equal to 0.05. The iron content in the seed shell from Sheda was 0.2436 mg g-1 more than those from Kuje. It was found that toxic element such as Pb was absent in the leaves, pods and seeds of moringa from both locations. This study confirmed presence of various macro as well micro elements and also proved the fact that there are variations in macro and trace minerals in moringa leaves, pods and seeds from different locations.

Ella et al. (1991) carried out a research to determine the effects of preculture in abscisic acid and exogenously zeatin was applied and their affects were studied regeneration of the plant from calli of rice. It was found that abscisic acid increased regeneration in the medium that was zeatin-free. The importance of zeatin lies in the fact that deficiency of zeatin, sets in the senescence. The deficiency was produced because of more zeatin transportation toward the roots. This fact was further verified by Ambler et al. (1992), who did a novel study by testing the xylem sap from decapitated vegetative and mature plants of nonsenescent and senescent sorghum (Sorghum bicolor L.) and analyzed them in order to check the concentration of cytokinins so as to determine whether the delayed leaf senescence of nonsenescent sorghums was linked to transport of greater quantities of cytokinins towards the roots. For field-grown plants, the amount of zeatin riboside (ZR) in xylem sap per gram
shoot dry weight was 1.51 times higher for the non-senescent sorghum as compared to senescent plants. He made conclusion that higher concentration of zeatin was moved to roots that caused senescence.

Jee et al. (1989) carried out experiments to optimize the composition of plant growth regulators which affected protoplast cultures and plant regeneration vigor of the mesophyll protoplasts in the Brassica oleracea L. Numerous plant growth regulators were applied and in the end it was revealed that zeatin in the amount of 4mg/L produced the best results by increasing the growth of plants grown in medium. Another characteristic of zeatin for enabling the plants to withstand the periods of high temperature with more vigor and efficiency was revealed by Cheikh et al. (1994), who studied the maize kernel distortion which was the result of high temperature. They studied the effect of high temperature on seed kernel distortion while keeping a control treatment and in the end it was revealed that temperature stressed maize kernels have a higher concentration of zeatin than those of grown at normal temperature. Thus they revealed the fact that shifts in hormone balance of kernels is one mechanism by which plants manage the high temperature by producing more zeatin.

Lee et al. (1988) conducted experiment to determine the effect of various cytokinins on the growth and development of callus of sesame. Results showed that cytokinins at high concentration inhibited the root development of sesame but enhanced the green part formation even at higher concentraton. Zeatin was the most effective among cytokinins that were tested, but shoot was not formed from the callus on any regeneration. Al-Hussein et al. (2006) applied zeatin in very small concentration on plants in medium along with one treatment of incubation for 1-2 weeks and on another treatment immediate light exposure was given. Results showed that incubation of 1-2 weeks gave better results while concentration of zeatin was of no matter. Okuse et al. (1995) studied the effect of different cytokinins on shoot regeneration from leaf explant of common cabbage (Brassica oleracea L.) and found that all cytokinins were effective in promoting the regeneration of plant from explant. As far as the concentraton of zeatin was concerned it was found that the concentration of zeatin was broader than that of other cytokinins. The studies have revealed the process and mechanism by which zeatin promotes the growth of plant by stating that zeatin is present in more concentrations in parts of plant where more growth and cell division occurs. Zeatin is also involved in carbohydrates mobilization as well as distribution to the sink where more carbohydrates are needed to cater the needs of rapidly increasing growth. This was proved by They reached to the conclusion that Zeatin riboside affected mainly the mobilization of carbohydrates and has less effect on protein mobilization. Zeatin on combining with carbohydrates increases growth. In most recent studies some scientists such as Kato et al. (2002) have revealed the fact by conducting an experiment in which they found that on combining the zeatin with glucose produces a compound called the Zeatin-o-glucoside (GOS). This compound had the highest growth promoting activity even 100 times more than that of zeatin and zeatin riboside and played a vital role in shoot greening of cucumber. These results suggested that in some developmental stages, the combination of cytokinins with a carbohydrate, such as glucose, was a key factors in controlling the shoot greening by roots. Lashar et al. (2008) conducted a experiment to optimize the zeatin concentration and in the end suggested that Optimum ZT concentration for cotton was 0.5-25 μM that yielded the best results as compared to other higher concentrations. Zeatin plays a vital role in keeping the plants green for a longer period of time.

References
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