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ALLELOPATHIC EFFECT OF PEARL MILLET (PENNISETUM GLAUCUM) SEEDS ON SEEDLINGS GROWTH OF THREE CEREALS

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ABSTRACT: Laboratory study was conducted to investigate allelopathic effects of seed aqueous extract of *Pennisetum glaucum* on seedling growth of three cereals; *Avena sativa*, *Triticum durum* and *Hordeum vulgare* Different levels of *P. glaucum* seed aqueous extracts concentrations (0%, 2%, 4%, 8% and 10%) were used to test its effect on the studied species. Results revealed significant allelopathic effects of seed aqueous extract *of P. glaucum* on radicle, coleoptile and total plant lengths. However, it was found that *Avena sativa* was the most susceptible and *Triticum durum* was the less sensitive on seed aqueous extract of *Pennisetum glaucum.*

KEYWORDS: *Pennisetum glaucum*, allelochemicals, allelopathic, cereals, seeds.

1 INTRODUCTION

Pearl millet constitutes an important source of dietary calories and protein [1], [2] in the daily diet of a large segment of the poor population in developing countries. Although it is consumed as a major staple food, the nutrient availability to the human gut is constrained by certain inherent antinutritional factors such as polyphenols and phytic acid [3]. Many studies have demonstrated that pearl millet whole grains are rich sources of phenolic compounds [4], [5]. Several studies have demonstrated that the outmost layers of the grains possess a high phenolic content [6], [7]. These compounds are also found in embryos and seed coat of grains [8], [9].

Phenolic acids consist of two classes: hydroxybenzoic and hydroxycinnamic acids [10]. Hydroxybenzoic acids are directly derived from benzoic acid and include gallic, p-hydroxybenzoic, vanillic, syringic, and protocatechuic acids, among others. The hydroxycinnamic acids include coumaric, caffeic, ferulic, and sinapic acids. Phenolic compounds have many roles: they prevent the oxidation of various food ingredients [11], regulated role in plant growth and morphogenesis and in the cell in response to stress and pathogens [12], [13].

Polyphenols also have several industrial applications such as in the production of paints, paper and cosmetics, as tanning agents and in the food industry as additives [14]. Phenolic acids have been shown to inhibit the in vitro growth of an assortment of fungal genera [15]. Phenolic compounds caused slow degradation and disrupt litter nitrogen nutrition [16]. Some phenolic compounds (catechol, coumarique, ferulique, gallique, gentistique, hydroxybenzoique, syringique et vanillique) also affect photosynthesis and mitochondrial metabolism. The operation affects all of the stomata and interacts with phytohormones [17]. Some authors [18] showed that p- coumaric acid at 10 ppm concentration inhibit rye, wheat and corn growths. This role played by phenolics is called allelopathy.

Allelopathy is an interference mechanism by which plants release chemicals which affect other plants; while it has often been proposed as a mechanism for influencing plant populations and communities [19]. Allelochemicals are generally inhibitors of the growth of roots, stems, leaves and overall plant growth. Several compounds are inhibitors of germination [20]. In most cases, the adverse effects of allelopathic result in mortality or a growth arrest.

Exposure of sensitive plants to allelochemicals can affect their germination, their growth and development. In fact, the germination of the seeds is then delayed or development of plants is inhibited [21]. Morphological changes were observed most often in the early stages of development [22]: effects on the extension of the stalk and the radicle. These variations can be observed in the post-emergence stage on the development of shoots and roots [23].

Allelopathy is considered as important in agriculture because it is exploited as a weed control strategy, alternative to the commercial herbicide dominated programs [24]. Incorporating allelopathy into natural and agricultural management systems may reduce the use of herbicides, insecticides, and other pesticides, reducing environment/soil pollution and diminish autotoxicity hazards. Considering importance of allelopathy and the observed adverse effects of Pearl millet seeds on some crops, we initiated the present study to find its possible allelopathic potential.

2 MATERIALS AND METHODS

Seeds from autochthonous pearl millet ecotype (KS) were collected, air dried at room temperature (25°C) and powdered. Aqueous extracts were prepared by soaking several concentrations of seeds powder (0-10-20-40-80-100 g/l) in distilled water at 25°C. After 24 h, the aqueous extracts was filtered. These extracts were tested against *Hordeum vulgare*; *Avena sativa* and *Triticum durum* on 2-folds of filter paper in Petri dishes. The filter papers were moistened with the respective extracts. Distilled water was used as a control. After 7 days, twenty seedlings were randomly taken out and plumule, radicle and total plant lengths were determined. All the bioassays, having 5 replicates, each with 25 seeds, were incubated at 25°C for one week. All the results were subjected to standard statistical analysis (ANOVA). The differences between the parameters were evaluated by Dunnett or Scott Knott test. The values of $p \leq 0.05$ when different of the control were considered statistically significant.

3 RESULTS

3.1 EFFECT OF AQUEOUS EXTRACT ON TOTAL PLANT LENGTH

Growths of the most species were significantly inhibited by the Pennisetum aqueous extracts (Fig. 1). Species in decreasing order of height were Avena (45%), Hordeum (44%) and Triticum (26%) respectively. Moreover, the higher is the concentration, the greater is the reduction of plant length except for wheat, where improved growth was noted till concentration of 80 g/l. For concentration up to this value, growth was declined by 26%. Correlations linking total plant height with concentrations are linear for barley and oats and polynomial for wheat.

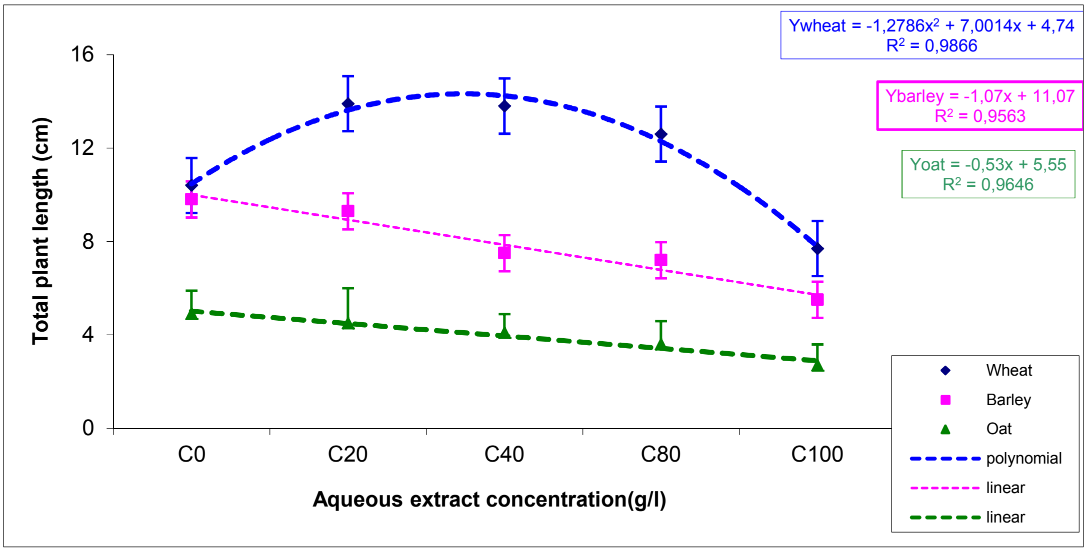

Fig. 1. Effect of Pennisetum aqueous extract on total plant length of three cereals (wheat, barley, oat)

3.2 EFFECT OF AQUEOUS EXTRACT ON RADICLE LENGTH

Root length of the seedlings for all species was significantly influenced by Pennisetum seed aqueous extract concentrations (Fig.2).. The inhibition at concentration 10% was significant for all tested plants. The highest concentration (100g/l) of Pennisetum seed aqueous extract caused 43% inhibition of root length for barley, 40% for oat and 30% for wheat compared with the control. For root growth, the least affected species is wheat. Maximum root length was recorded at 20 g/1 concentration for wheat and declined with increase in the concentrations, but reminded higher than control till 80g/l concentration. Correlations linking radicle height with concentrations are of the same type as for the total plant length.

3.3 EFFECT OF AQUEOUS EXTRACT ON PLUMULE LENGTH

Pennisetum aqueous extract improve plumule length of wheat till concentration 8%. More than this value, coleoptile length was decreased by 18%. The highest length was obtained for 4% concentration: amelioration was about 60% (Fig.3).

Oat was more sensitive where the inhibition reached 80%, while barley was less susceptible (47%) for the same aqueous extract concentration (10%). A little promotion on plumule length of barley can be seen at 2% concentration but the increase was not significant. Correlations linking plumule height with concentrations are polynomial for barley and wheat and logarithmic for oat.

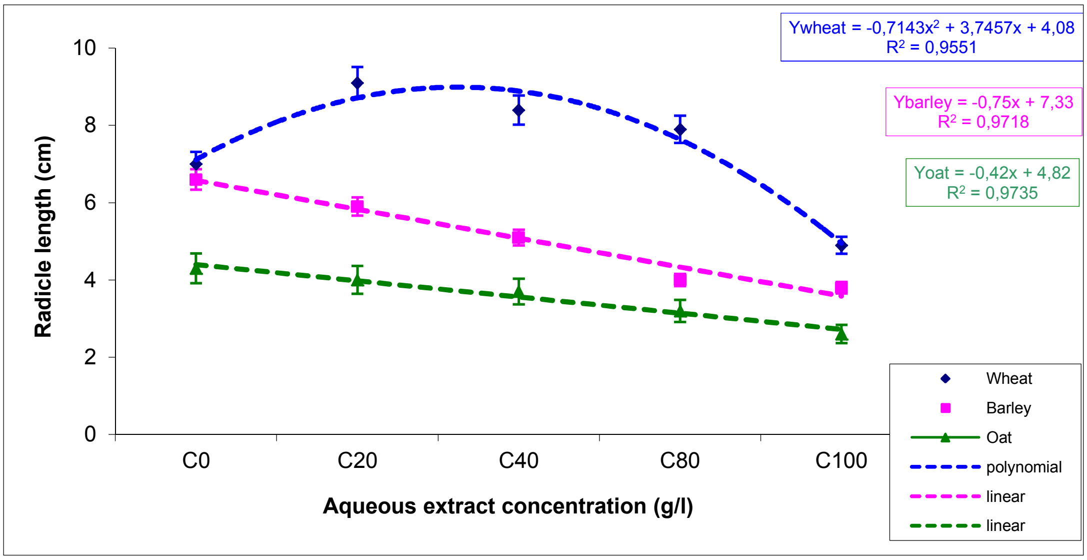

Fig. 2. Effect of Pennisetum aqueous extract on radicle length of three cereals (wheat, barley, oat)

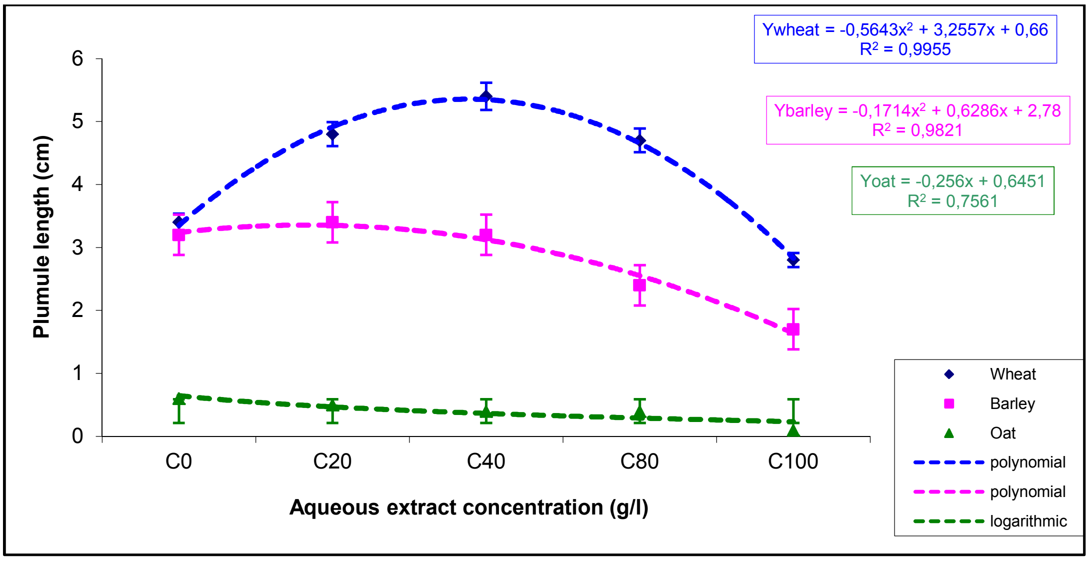

Fig. 3. Effect of Pennisetum aqueous extract on plumule length of three cereals (wheat, barley, oat)

4 DISCUSSION

In the present study, allelopathic effects of *pennisetum glaucum* seeds were observed on seedlings growth of three cereals: barley, oat and wheat.

Allelopathic effect of pear millet against other species is signalled in many studies [25], [26], [27], but this effect was reported in leaves, stems and roots [28], [29], [30] but has never been approached for Pennisetum seeds. Some authors had cited allelopathic effect of seeds in many plants [31], [32], [33], [34], [35].

Seeds aqueous extract of *Pennisetum glaucum* inhibited or stimulated radicle, coleoptile and total plant lengths in different ways, depending on concentration levels used, on receiver species and with organ treated. This result is corroborated by [36]. These authors reported that allelopathy involves both inhibiting and stimulatory effects and stimulation can observe for low allelochemicals aqueous extract concentrations. In fact, for wheat, decrease was more important for radicle length than for coleoptile length. While for oat, coleoptile was reduced twice than radicle. For barley, reduction in the growth of barley seedlings was more drastic for coleoptile than for radicle but the difference was not significant.

For total plant length, we have found that the higher is the concentration, the greater is the reduction of plant length except for wheat, where improved growth was noted till concentration of 80 g/l. Similar results were found by [37], [38], [39]. The inhibition at concentration 10% was significant for all tested plants. [40] found that allelochemicals that inhibit the growth of some species at certain concentrations might in fact stimulate the growth of the same or different species at different concentrations. In fact, Wheat seems to be the less sensitive species to allelopathic effect of Pennisetum seeds extract, while oat and barley respond in the same manner and exhibited a stronger inhibitory effect.

With respect to the growth of seedlings, the seed aqueous extract inhibited the growth of the coleoptile for all species at the highest concentration. The most affected was Oat where inhibition reached about 80%. The concentrations of aqueous extract 2, 4, and 8% stimulated the growth of the coleoptile of wheat. These same treatments completely inhibited the growth of oat coleoptile. Concentration less than 4% promoted coleoptile length of barley.

The comparative analysis for radicle length for all species showed that Pennisetum seed aqueous extract concentrations had a significant effect. The different species reacted in the same manner as for the total plant length and wheat reminded the least affected species. Many studies indicate the release by seeds of phototoxic chemicals during the preparation of aqueous extracts [34], [35].

The observed different phytotoxicity of *P. glaucum* may be attributed to the presence of variable amount of water-soluble inhibitory chemicals which hampers or promotes growth of the three cereals. Its effectiveness on seedlings growth suggests that seeds of *P. glaucum* may act as a source of allelochemicals. In fact, *Pennisetum glaucum* is a rich source of phenolic compounds [3], [41] and these phenolics appear to be among the key compounds [42]. In fact, they were identified as the allelopathic agents more often than all other classes of compounds combined [43]. Several authors [44] suggested that the concentration of coumaric acid was greatest and sufficient to reduce growth of other species. [45] also found that concentration of p-coumaric was the highest followed by ferulic acid. Many authors reported that phenolic compounds inhibit cell division [46] reduce root growth [47]; affect cell elongation [48], [49]; slowing the incorporation of amino acids [50]; can causes changes to cell ultrastructure [51] and affect ion uptake, membrane permeability, photosynthesis and phytohormone balance [52]. It is also possible that the cell elongation was affected by seed extracts of pearl millet. It was demonstrated that many allelochemicals inhibited gibberellin and indole acetic acid induced growth [53]. One of the suggested explanations for disruption of seedling growth and development during allelopathy stress is modification in mitochondrial respiration leading to decreased supply of ATP for all energy demanding processes [54].

Inhibition of seedling growth in allelopathy stress conditions may be therefore a result of decreased ion uptake. A root is the first organ to come into contact with allelochemicals in the rhizosphere, thus the effect of allelochemicals on ion uptake is particularly important. There is also much data on the effect of allelochemicals on membrane bound enzymes e.g. proton pumping ATPase localized in plasma membrane (H+-ATPase). H+-ATPase inhibition results in reduction in mineral and water uptake by roots and as a consequence leads to a strong effect on essential plant functions such as photosynthesis, respiration or protein synthesis leading finally to reduction of growth [54].

Responses of the three cereals to Pennisetum seeds extract measured in seedling growth differed among receiver species. In fact, allelopathic effect depends among donors' species and those receivers [55],[56],[57].

Strong allelopathic effect performed by others seeds aqueous extracts on oat was mentioned by [58],[59],[60],[61]. They attributed this inhibition to the action of some secondary metabolites such as benzoxazolinones which hampers auxin oat coleoptile synthesis.

Wheat demonstrated the less negative response to allelopathic effect of Pennisetum seeds extract. These results were noted in the studies of [62],[63]. They found that *P. harmala* à 1 % and *A. altissima* à 1 % et à 3 % stimulated coleoptile wheat length and inhibited radicle length. [37] noted that *Populus deltoides* aqueous extract less than 5% stimulated wheat coleoptile growth. Wheat coleoptile length was promoted by *Beta vulgaris* extract till 8% concentration [64].

Low allelopathic effect of Pennisetum on wheat seems to be due to antagonism effect between the two species which cancels and reduces the toxic effect of allelochemicals. In fact, wheat releases adversity of allelochemicals (phenolic acids, cyclic hydroxamic acids, short-chain fatty acids as well as many other phytotoxic chemicals) into the environment [65],[66].

5 CONCLUSION

The present investigation revealed that Pennisetum seeds aqueous extracts had effects on seedlings growth of three cereals. *Pennisetum glaucum* may act as a source of allelochemicals. Further studies are suggested to clarify the possible physiological mechanism related to allelopathic effect on plants.

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