RESEARCH ARTICLE Agricultural Science Digest, Volume 40 Issue 2: 159-162 (June 2020)

Soybean [*Glycine max* (L.) Merrill] Shows No Change in Predatory Arthropods Population after Mutagenesis in Northern Ghana

I.A. Wahab, S. Adu-Acheampong, I.K. Addai

10.18805/ag.D-245

ABSTRACT

Predatory arthropods dynamics can be a proxy measure for arthropods pest dynamics in an agro-ecosystem. We investigated the diversity of predatory arthropods associated with soybean lines developed through mutagenesis along with NPK fertilizer effect on the lines. The soybean lines were 0 Gy, 150 Gy, 200 Gy, 250 Gy and 300 Gy and two NPK fertilizer rates at 0 kg ha^{-1} and 60 kg ha^{-1} in a factorial design with three replications in CRD. The results indicated that predatory arthropod diversity associated with the four soybean lines were statistically similar. Also, fertilizer did not significantly affect predatory arthropod dynamics. We conclude that there is a similar trend of predatory arthropod diversity within the different soybean lines. As a result, we recommend the best performing line (s) after screening, to farmers for adoption because arthropod pests will not be a problem to consider in choosing any line (s) over others.

Key words: Agroecosystems, Fertilizer, Mutagenesis, Predatory Arthropods, Soybean.

INTRODUCTION

Predatory arthropods can potentially prevent crop damage from reaching economic levels in agroecosystems. This is because they contribute to the delay in pest population build up as a result of diverse interactions with pest populations (Getanjaly *et al*., 2015). As a result, natural enemies have been used as key components of major pest control programs worldwide (Panizzi, 2013; Chailleux *et al*., 2013; Yang *et al*., 2014). For instance, predators and parasitoids are the main pest control methods within soybean ecosystem in parts of the USA and China (Getanjaly *et al*., 2015; Yang *et al*., 2014; Underwood, 2017). Studies also show that, the population dynamics of herbivorous arthropods are directly and positively correlated with their natural enemy population (Underwood, 2017; Dib *et al*., 2010).

The relationship between predatory arthropods and their prey can be used as a proxy measure of pest population in an agroecosystem (Griffin *et al*., 2013; Crawley, 2009). This can be inferred from the law of equilibrium of arthropod population dynamics which states that “the rate at which prey population rise decreases when predator population rises” meaning before predator population could rise there has to be an increase in prey population (including pests) (Begon *et al*., 2009; Vandermeer and Goldberg, 2013).

Soybean is a multipurpose leguminous crop and one of the cheapest protein sources cultivated across the world (Sharma *et al*., 2016; Gunathilake *et al*., 2019). Depending on the type and the stage, soybean can tolerate up to 35 per cent defoliation before flowering, however, after seed pod filling, foliage loss above this threshold can cause economic loss (Temple *et al*., 2009). Due to its ease of controlling arthropods, natural enemies can be used to achieve pest control when managed well without the need to augment with chemical pesticides (Panizzi, 2013; Chailleux *et al*., 2013; Yang *et al*., 2014). However, studies elsewhere indicate that mutagenesis can change the properties of some leguminous crops which may also increase its susceptibility to pest attacks (Shekar, 2017; Singh and Sadhukhan, 2019).

In line with that, this study was set out to evaluate the attractiveness or otherwise of four newly developed soybean lines (150Gy, 200Gy, 250Gy and 300Gy, through mutagenesis from bombardment with gamma rays) for predatory arthropods which will see these lines as easy food sources. Our hypothesis was that, mutagenesis has not rendered the new lines more susceptible to arthropod pest attacks. If so, there will be no significant difference between the predatory arthropod population of the newly developed mutants and the old line (0Gy). This is because high presence of predator population on a variety would signify high presence of prey population which includes arthropod pests. We specifically sampled for the predatory arthropods associated with the soybean mutant lines compared with the old variety (0Gy) and also measured the indirect impact (if any) of NPK fertilizer on them.

Department of Agronomy, University for Development Studies P.O. Box TL1882, Nyankpala-Tamale.

Corresponding Author: S. Adu-Acheampong, Department of Agronomy, University for Development Studies P.O. Box TL1882, Nyankpala-Tamale. Email: saduacheampong@uds.edu.gh

How to cite this article: Wahab, I.A., Adu-Acheampong, S. and Addai, I.K. (2020). Soybean [*Glycine max* (L.) Merrill] Shows No Change in Predatory Arthropods Population after Mutagenesis in Northern Ghana. Agricultural Science Digest. 40(2): 159-162.

Submitted: 11-03-2020 **Accepted**: 18-04-2020 **Published**: 16-05-2020

MATERIALS AND METHODS

The experiment was conducted at the University for Development Studies (UDS) experimental site (farming for future) in Nyankpala in 2019. The site is located at longitude 0°58' W and latitude 9°25'N with an altitude of 183 m above sea level. Temperature pattern varies throughout the year with an annual average of about 34°C but could rise to a maximum of 42°C within the year. The landscape within the study area is characterized by natural savanna vegetation with tree density of about 10 to 100 trees ha^{-1} (Lawson and Issahaku, 2013).

Experimental materials

The soybean lines used for this study were acquired from the University for Development Studies Agronomy Department. These lines are still under evaluation and yet to be released as varieties. The newly developed lines are relatively smaller in size compared to the normal soybean seeds. The original variety (0Gy or Jenguman) has high shattering rate compared to the mutant lines. The mutant lines take more than 100-days to mature.

Cultural practices and experimental design

After field preparation, the site was divided into plots of 4 m x 3 m. Planting was done at 75 cm by 15 cm at a depth of approximately 3 cm within each plot. Soybean lines were sowed at 3 seeds per hill using dibber and covered with soil. In all, there were 48 stands after seed germination per plot. There were 30 plots for the study in total. Manual weeding was done using hoe on the second and the seventh week after sowing to reduce weed competition. NPK-15-15-15 fertilizer was applied at 0Kg/ha and 60Kg/ha to treated fields six weeks after germination. The study used a 5 x 2 factorial design with three replications in Complete Randomized Design (CRD).

Predatory arthropod sampling

We collected data after the first weed control with sweep net and visual observation. We took twenty sweeps per plot, after which predatory arthropods were either identified using visual cues or sent to the entomology laboratory of the University for Development Studies for identification to the best possible taxon. Data was collected on four occasions at two weeks interval.

RESULTS AND DISCUSSION

In general, there were seven predatory arthropod groups associated with all soybean lines based on morphospecies during the growth period. The total number of predatory arthropods recorded was 1282 belonging to 5 orders (Hemiptera, Neuroptera, Coleoptera, Mesostigmata and Araneae). The predatory arthropods were collected at various stages of growth of the soybean lines (Table 1). There was no statistically significant difference in predatory arthropod diversity and abundance between the control variety (0Gy) and the mutant lines ($P > 0.05$) (Fig 1). Also, there was no statistically significant difference between soybean lines giving NPK 15-15-15 and those without NPK 15-15-15 ($P > 0.05$) (Fig 2). Some of the most abundant arthropod pests encountered in the study were wireworms (*Melanotus* spp.), Soybean loopers (*Chrysodeixis* spp.) Bean leaf beetles (*Cerotoma* spp.) and the Fall armyworm (*Spodoptera frugiperda*).

Predatory arthropod species that were found to be associated with these soybean lines are known to be beneficial to the plants because they feed on arthropod pests associated with the crop plant. Our study shows that the six

Table 1: A list of predatory arthropod species associated with soybean lines at UDS experimental field Nyankpala.

Common name	Scientific name	Order
Big eyed bug	Geocoris spp.	Hemiptera
Greenlace wing	Chrysopa spp.	Neuroptera
Ladybird Beetle	Coccinella transversalis	Coleoptera
Damsel bug	Nabis spp.	Hemiptera
Spined Soldier bug	Podisus maculiventris	Hemiptera
Predatory mite	Phytoseiulus spp.	Mesostigmatus
Arachnid	Araneae spp.	Araneae

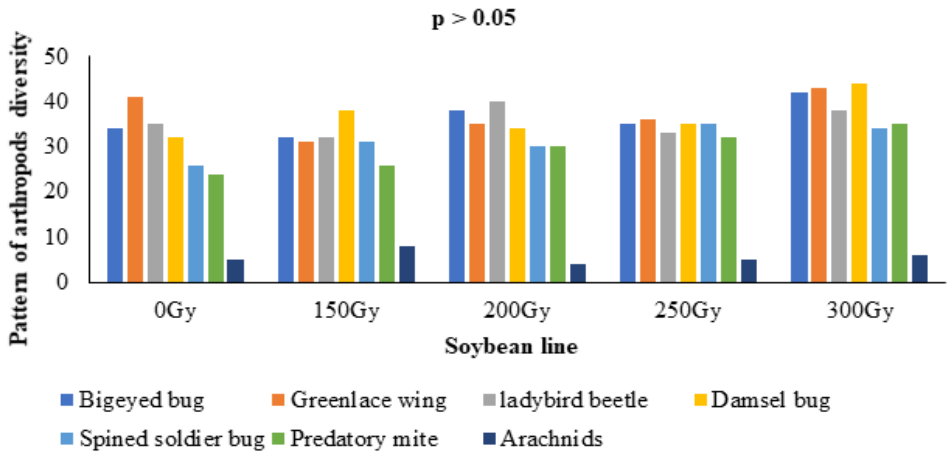

Fig 1: Comparing predatory arthropod diversity of four soybean lines after mutagenesis in Ghana.

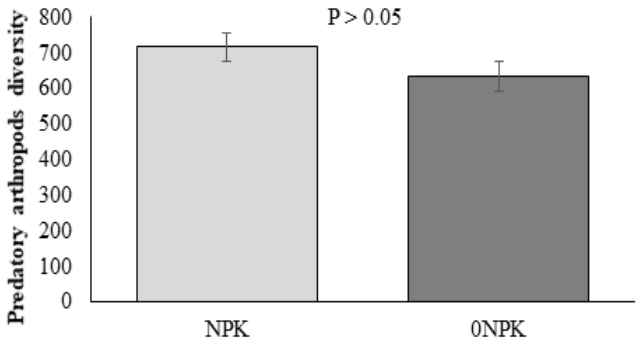

Fig 2: Soybean plots with and without fertilizer application.

predatory arthropods recorded on these soybean lines were also observed on a previous study by Abdul (2006) where ten natural enemies including Ladybird beetle, Predatory spiders, Damsel bug and Greenlace wing were also recorded on soybean. The results of the study also revealed that mutagenesis of the (0Gy) soybean variety did not increase the lines affinity or attractiveness to pest with evidence from the indirect impact on the diversity of predatory arthropods they attract which are statistically similar. Although, arthropod pests were not a big problem in the study, wireworms (*Melanotus* spp), Soybean loopers (*Chrysodeixis* spp.) Bean leaf beetles (*Cerotoma* spp.), the Fall armyworm (*Spodoptera frugiperda*) and whiteflies (*Bemisia tabaci*) were observed feeding on the leaves, husks and seeds at various stages of plant as reported elsewhere (Singh and Singh, 1990; Hartman *et al*., 2015). In literature such mutagenesis can potentially change some properties of plants and render them more susceptible to serious pest attacks (Narusaka *et al*., 2003; Scholz *et al*., 2014).

The study further revealed that, the population of predatory arthropods on the NPK applied fields and no NPK applied fields were not statistically significant. Even though there was a slightly high abundance of predatory arthropods on plots given fertilizers compared to those without fertilizers. This finding agrees with findings of another study that reported that the application of fertilizers rarely affected arthropod directly, but influenced the morphological, biochemical and physiological characteristics of host plants hence improving nutritional condition of herbivores (Lu *et al*., 2007; Shikano, 2017; War *et al*., 2018; Han *et al*., 2019). This might have been the case with this study. Under such conditions predators that prey on these herbivores may also benefit indirectly because there will likely be an increase in the population of their prey as a result of the extra vegetative growth through fertilization.

CONCLUSION

We conclude from this study that, the soybean mutant lines (0Gy, 150Gy, 200Gy, 250Gy and 300Gy) were associated with similar predatory arthropods and that these arthropods diversity were not statistically significant between the different soybean lines. Also, NPK and no NPK applied fields had statistically similar predatory arthropods. We therefore recommend that the best performing line can be given out to farmers without worrying about its attractiveness to arthropods compared to other lines after screening for other performance indicators.

REFERENCES

Abdul, M. (2006). Arthropod fauna on different growth stages of soybean crop. M.Sc. Thesis. Bangladesh Agriculture University Mymensight.

Begon, M., Mortimer, M., Thompson D.J. (2009). Population ecology: a unified study of animals and plants. John Wiley and Sons.

Chailleux, A., Bearez, P., Pizzol J., Amiens-Desneux, E., Ramirez-Romero R., Desneux, N. (2013). Potential for combined use of parasitoids and generalist predators for biological control of the key invasive tomato pest *Tuta absoluta*. Journal of Pest Science. 86: 533-541.

Crawley, M.J. (2009). Natural enemies: the population biology of predators, parasites and diseases. John Wiley and Sons.

Dib, H., Simon, S., Sauphanor, B., Capowiez, Y. (2010). The role of natural enemies on the population dynamics of the rosy apple aphid, *Dysaphis plantaginea* Passerini (*Hemiptera*: *Aphididae*) in organic apple orchards in south-eastern France. Biological Control. 55: 97-109.

Dzogbefia, V.P., Arthur, P., Zakpaa, H. (2007). Value Addition to Locally Produced Soybean in Ghana: Production of Soy Sauce Using Starter Culture Fermentation. Journal of Agricultural Science. 5: 38-46. doi: http://dx.doi.org/10.4314/just.v27i2.33036.

Getanjaly, V.L.R., Sharma, P., Kushwaha, R. (2015). Beneficial arthropods and their value to agriculture. Research Journal of Agriculture and Forestry Sciences. 3: 25-30.

Griffin, J.N., Byrnes, J.E., Cardinale, B.J. (2013). Effects of predator richness on prey suppression: a meta analysis. Ecology. 94: 2180-2187. doi: https://doi.org/10.1890/13-0179.1.

Gunathilake, D.M.C., Bhat, J., Singh, I.R., Kahandawala, K.A. (2019). Dynamics of the physical properties of soybean during storage under tropical condition. Legume Research-An International Journal. 42: 370-374.

Han, P., Becker, C., Le Bot, J., Larbat, R., Lavoir, A.V., Desneux, N. (2019). Plant nutrient supply alters the magnitude of indirect interactions between insect herbivores: From foliar chemistry to community dynamics. Journal of Ecology. https://doi.org/10.1111/1365-2745.13342.

Hartman, G.L., Rupe, J.C., Sikora, E.J., Domier, L.L., Davis, J.A., Steffey, K.L. (Eds.). (2015). Compendium of soybean diseases and pests. St. Paul, MN: American Phytopatho--logical Society.

Lawson, I., Issahaku, A. (2013). Time of planting and weed suppre--ssion abilities of some legumes intercropped with maize in the Guinea savanna zone of Ghana. Agriculture and biology Journal of North America. 4: 358-363. doi:10.5251/abjna.2013.4.4.358.363

Lu, Z.X., Yu, X.P., Heong, K.L., Cui, H.U. (2007). Effect of nitrogen fertilizer on herbivores and its stimulation to major arthropod pests in rice. Rice Science. 14: 56-66.

Narusaka, Y., Narusaka, M., Seki, M., Ishida, J., Nakashima, M.,

Kamiya, A., Enju, A., Sakurai, T., Satoh, M., Kobayashi, M., Tosa, Y. (2003). The cDNA microarray analysis using an Arabidopsis pad3 mutant reveals the expression profiles and classification of genes induced by *Alternaria brassicicola* attack. Plant and Cell Physiology. 44: 377-387.

Panizzi, A.R. (2013). History and contemporary perspectives of the integrated pest management of soybean in Brazil. Neotropical Entomology. 42: 119-127. https://doi.org/10.1007/s13744-013-0111-y

Plahar, W.A. (2006). Overview of the soybean industry in Ghana. CSIR-food research institute, PO Box m. 20, Accra, Ghana. In Workshop on soybean protein for human nutrition and health. www. csir.org.gh/fri. html.

Scholz, S.S., Vadassery, J., Heyer, M., Reichelt, M., Bender, K.W., Snedden, W.A., Boland, W., Mithöfer, A. (2014). Mutation of the Arabidopsis calmodulin-like protein CML37 deregulates the jasmonate pathway and enhances susceptibility to herbivory. Molecular Plant. 7(12): 1712-1726. https://doi.org/10.1093/mp/ssu102

Sharma, P., Dupare, B.U., Patel, R.M. (2016). Soybean improve--ment through research in India and socio-economic changes. Legume Research-An International Journal. 39: 935-945.

Shekar, G.C. (2017). Induced mutations in soybean (*Glycine max* L.). Legume Research-An International Journal. 40: 1012-1019.

Shikano, I. (2017). Evolutionary ecology of multitrophic interactions between plants, insect herbivores and entomopathogens. Journal of Chemical Ecology. 43: 586-598.

Singh, O.P., Singh, K.J. (1990). Insect pests of soybean and their management. Indian Farming. 39: 9-38.

Singh, P.K., Sadhukhan, R. (2019). Ems and gamma radiation induced mutation in grasspea (*Lathyrus sativus* L.). Legume Research-An International Journal. 42: 300-307.

Snyder, W.E., Snyder, G.B., Finke, D.L., Straub, C.S. (2006). Predator biodiversity strengthens herbivore suppression. Ecology letters. 9: 89-796. https://doi.org/10.1111/j.1461-0248.2006.00922.x

Temple, J.H., Leonard, B.R., Davis, J., Fontenot, K. (2009). Arthropodicide efficacy against red banded stink bug, Piezodorus guildinii (Westwood), a new stink bug pest of Louisiana soybean. Midsouth Entomology. 2(2009): 68-69.

Underwood, D.L.A. (2017). Arthropods as predators and parasitoids. Access on 15th June 21, 2019. http://www.csulb.edu/~dlunderw/entomology/16-Arthropodsaspredators.pdf

Vandermeer, J.H., Goldberg, D.E. (2013). Population ecology: first principles. Princeton University Press.

War, A.R., Taggar, G.K., Hussain, B., Taggar, M.S., Nair, R.M., Sharma, H.C. (2018). Plant defence against herbivory and insect adaptations. AoB Plants. 10(4): ply037.

Yang, N.W., Zang, L.S., Wang, S., Guo, J.Y., Xu, H.X., Zhang, F., Wan, F.H. (2014). Biological pest management by predators and parasitoids in the greenhouse vegetables in China. Biological Control. 68: 92-102. https://doi.org/10.1016/j.biocontrol.2013.06.012