Glyphosate Effects on the Growth, Yield and Protein Concentration of Groundnut (*Arachis hypogaea*) In Jos Metropolis

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Abstract: This experiment was conducted at Federal College of Forestry, Jos to determine the effect of glyphosate herbicide on the growth and yield parameters as well as the protein concentration of groundnut (*Arachis hypogaea*). The experiment consist of Randomized Complete Block Design (RCBD) where four treatments were involved in which the control (T_o) is without glyphosate, while T_1, T_2, and T_3 contained 4ml, 6ml and 8ml of glyphosate herbicide per 100ml water solution respectively applied per $4m^2$ experimental plot. The treatments were replicated four times. The herbicide was applied to the plots three times with the control weeded using hoe. Biuret method of protein analysis was also used to determine the protein concentration of the yield. Analysis of variance (ANOVA) was used to analyze the results and where differences occur among the means, Duncan Multiple Range Test was used to separate the means. Parameters such as plant height, leaf count, stem girth, number of flowers, yield and protein concentration were examined. The result indicates that significance difference occur in the plant height and leaf count with T_0 having the highest mean value 22.98 (plant height) and 275.24 (leaf count). T_0 recorded the highest mean value of 2.42 for stem girth and 28.30 for number of flowers. The yield as well as the protein concentration also recorded significant results with the highest mean values occurring in T_0 with values of 0.354 and 13.53 respectively. This result is an indication of the effects glyphosate herbicide exhibit on the growth, yield parameters and protein concentration of groundnut.

***Keywords*:** *Glyphosate, Groundnut, Growth, Protein concentration, Yield.*

INTRODUCTION

Groundnut (peanut) (*Arachis hypogaea* L.) is one of the world's most popular oil seed crops which is grown as an annual plant but perennial growth is possible in climates which are warm until harvest. Groundnut can best be grown on a well-drained sandy, loamy or sandy clay loam soil with a pH of 5.5-6.0 and high soil fertility are ideal for groundnut (Aparna *et al*., 2013). Cultivated groundnut (*Arachis hypogaea* L.) belongs to the genus *Arachis* in the sub-tribe Stylosanthinae of the tribe Aeschynomenea and family of leguminosae. It is a self-pollinated, tropical annual legume. Groundnut is grown on 26.4 million hectare worldwide, with a total production of 37.1 million metric tonnes and an average productivity of 1.4 metric tons /ha (Kurrey and Jain, 2018). Groundnut is an excellent source of plant nutrients, it contains 45-50% oil, 27-33% protein as well as essential minerals and vitamins (Ahmed *et al*., 2011) with some dietary fibres in small quantity. The nutrient found in groundnuts, including folic acid, phyto-sterols, phytic acid and resveratrol have anti-cancer effects (Gayathri, 2018).

Developing countries in Asia, Africa and South America account for about 97 % of World groundnut area and 95% of total production (Johnny *et al*., 2014). Nigeria is the third highest producer of groundnut in the world after China and India with a production of 16,114,231, 6,933,000 and 2,962,760 tons respectively (FAO, 2001). Groundnut has contributed immensely to the

development of the Nigerian economy. From 1956 to 1967, groundnut products including cake and oil accounted for about 70% of total Nigeria export earnings, making it the country's most valuable single export crop ahead of other cash crops like cotton, oil palm, cocoa and rubber (Harkness *et al*., 1976).

In groundnut production, weeding is important between 4 to 8 weeks after sowing (Santelmann and Hill, 1969) in order to have a good crop yield. Nutrient losses due to crop-weed completion has been described to be about 38.8, 9.2 and 23.3 for each of Nitrogen, Phosphorus and potassium in $kgha^{-1}$ respectively (Naidu *et al.* 1982). As necessary as weeding is, it is regarded as one of the most tedious farm works. The establishment of chemical herbicides has brought a great relief to farmers. Herbicides can do works that over 100 farmers will do and their effects are more lasting than the use of mechanical methods of weeding. However, their residual effects can cause great damage to living organisms.

Glyphosate with the chemical name [*N*-(phosphonomethyl) glycine)] is the most broadly used herbicide worldwide since the introduction of glyphosate-resistant (GR) plants (Coupe *et al*., 2012). The high solubility of glyphosate has brought about some concerns on its possible environmental effects despite the report on its safety on animals and humans (Cerdeira and Duke, 2006). Despite the importance of this herbicide, it has been reported to interfere with the uptake of essential minerals in agricultural crops. One of the mechanism of reaction of glyphosate is to block an enzyme called 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) that plants need to make amino acids and protein (Hoagland and Duke, 2002). Shikimic acid is an important intermediate that is essential in the biosynthesis of aromatic amino acids (phenylalanine, tyrosine, tryptophan) as well as in the synthesis of some secondary metabolites like alkaloids, flavonoid, lignin and aromatic antibiotics. Glyphosate in its action, binds tightly to EPSPS and therefore prevents the binding of the enzyme to its substrate (Jasim *et al*., 2016). This therefore inhibits the production of some essential nutrients and the secondary metabolites produced from shikimate biosynthesis. In view of this, this study is aimed at investigating the effect of glyphosate herbicide on the growth, yield as well as the protein concentration of groundnut (*Arachis hypogaea*).

MATERIALS AND METHODS

Study Area

The experiment was conducted at Federal College of Forestry, Jos. The College lies between Southern humid regions of Guinea Savannah ecologically zone of Nigeria with temperature range between 10º and 32º depending on the season of the year. It is of latitude 9.56ºN and 8.53ºE in the middle belt of Nigeria. It has a cool climatic condition with a sandy loamy soil (Pam, 2009).

Method

The experimental site was cleared and debris were removed. The plots were properly randomized, using Randomized Complete Block Design and were then measured. The beds were constructed with proper mixing of the soil before demarcating each plot.

Herbicide Application

Glyphosate herbicide was applied before the crop was planted after seed bed preparation. The treatments consist of four different application rates of the herbicide. The control treatment was weeded manually without the use of the herbicide. The second treatment consists of 4ml of glyphosate in 996ml of water to make up 1000ml solution. The third treatment consist of 6ml of glyphosate in 994ml of water and the last treatment consist of 8ml of glyphosate in 992ml of water.

Planting operation

The groundnut was planted by drilling method on a flat seed bed with sandy loamy soils. Groundnut was planted by sowing at a distance of 15cm between plants and 30cm between rows with the use of small hoe, 3 seeds per hole was planted but later reduced to two per stand.

Protein Analysis

The protein analysis was carried out using Biuret method. Prior to the laboratory analysis, the groundnut sample was pulverized using an electric blender and 1g of the sample was weighed using a weighing balance (HX 302T). The sample was suspended in 10ml of 70% ethanol and the oil washed off with 1ml petroleum ether to prevent interference. 4ml biuret reagent was added to 1ml of the 10 fold diluted sample. The mixture was rapidly cooled and the optical density was read using a spectrophotometer at a wavelength of 280nm wavelength.

Results and Discussion

Plant Height

The result obtained shows that the plant height differed across the different groups and it is based on the level of glyphosate herbicide applied. It was indicated in the result (Table 1) that there is significance difference in the plant height for the different treatments used. The highest mean value was observed in the control with the second highest occurring in T_1 (22.15). The effect of the herbicide however showed the most in the group with the highest glyphosate with mean value (21.78). Simic *et al*. (2011) explained that

application of flurochloridone combined with s-metolachor produced an effect in the height of sunflower when different varieties were grown.

Table 1: Effect of Glyphosate herbicide on the growth parameters of groundnut (*Arachis hypogaea*)

Treatments	Plant Height (cm)	Leaf Count	Stem Girth
T_0	22.98[a]	275.24[a]	2.42[a]
T_1	22.15[b]	273.76[a]	2.24[b]
T_2	21.99$_b$	254.48[b]	2.24[b]
T_3	21.78[b]	255.69[b]	2.25[b]
S.E.M	0.18	3.54	0.02
L.S	*	*	*

Means in the same column having the same superscript are not significantly different at 5% level of probability

Leaf Count

The leaf count of the *Arachis hypogaea* clearly shows that the different concentrations of the glyphosate herbicide have negative effects on the number of leaves (Table 1). The result shows that significant difference occurs among the different treatments. The highest mean value occur in T_0 (275.24) with the second highest occurring in T_1 (273.76). The reduction in the number of leaves in T_2 and T_3 could be as a result of glyphosate's effect on the rate of photosynthetic activities. Glyphosate has been reported to inhibit chlorophyll biosynthesis (Fedtke and Duke, 2005) and it can as well stimulate the degradation of chlorophyll in the photosynthetic units of plant. The inhibition of the major photosynthetic components in plant, which is chlorophyll brings about conservation of the inherent nutrients in plants hence, reduction in the number of leaves by T_2 and T_3.

Stem Girth

The Stem girth of the different treatments shows differences in the values obtained (Table 1). These differences were found to be significant between the control and the experimental units. The highest mean value occurred in the control (2.42). T_1, T_2 and T_3 have mean values 2.24, 2.24 and 2.25 respectively. The three treatments are however not significant from one another. They are however statistically similar to one another even despite the differences in the values between T_1, T_2 and T_3. The observed differences in the collar girth between the experimental treatments and the control could be due to mechanism of action of glyphosate in disrupting plant growth. Glyphosate penetrates the plant tissues, after translocation through the vascular tissues (Satchivi *et al*., 2000) and hence alter the lateral meristem growth, the cell responsible for stem tissue expansion. This result is similar to that of Obidola *et al*. (2019) in which significant difference was reported in cowpea seeds treated with cypermethrin pesticide before planting.

Table 2: Effect of glyphosate herbicide on the yield parameters of groundnut (*Arachis hypogaea*).

Treatments	Number of Flowers	Yield (kg/m^2)
T_0	28.30[a]	0.354[a]
T_1	26.46[b]	0.314[b]
T_2	21.18[c]	0.310[b]
T_3	19.14[d]	0.255[c]
S.E.M	0.42	2.42
L.S	*	*

Means in the same column having the same superscript are not significantly different at 5% level of probability.

Number of Flowers

The mean values for the number of flowers shows that differences occur among the different application rates of glyphosate herbicide as observed in table 2. The differences are seen to be significantly different from one another as indicated in table 3. The highest mean value is as observed in the table above (28.30) indicative of no glyphosate effect in the control. However, treatments T_1, T_2 and T_3 have mean values 26.46, 21.18 and 19.14 respectively which shows that the number of leaves obtained is in accordance with the herbicide application rates. Glyphosate affect flower formation by affecting the major components involved in the flower such as the anther and the petals there by shrinking the flowers inhibiting the formation of new flowers. The result stated here is in line with the published work by Londo *et al*. (2014) which states that glyphosate application to *Brassica rapa* and *Brassica nigra* significantly reduced the duration of flowering.

Yield

The yield obtained for the different treatments are reflective of the glyphosate effect. Significant difference occur in the different treatments (Table 2). T_1 (0.354) is significantly different from the control and from T_2 and T_3 whose mean values are 0.310 and 0.255 respectively. The yield obtained from each treatment are reflective of the various concentrations used. The differences in the yield obtained for each of the treatments could be as a result of the growth and yield parameters as exhibited by the plants as observed in the other results above. This result is a confirmation of the earlier published work by Ghosheh *et al*. (2002) in which there was a significant reduction in the yield (64-84%) of sorghum and corn that were treated with pyrithiobac herbicide. Similarly, O'Sullivan and Thomas, (2001) reported about 22% and 13% reduction in the yield of cabbage and pepper respectively after treatment with sulfonyl urea herbicide CGA 152005.

Protein Content

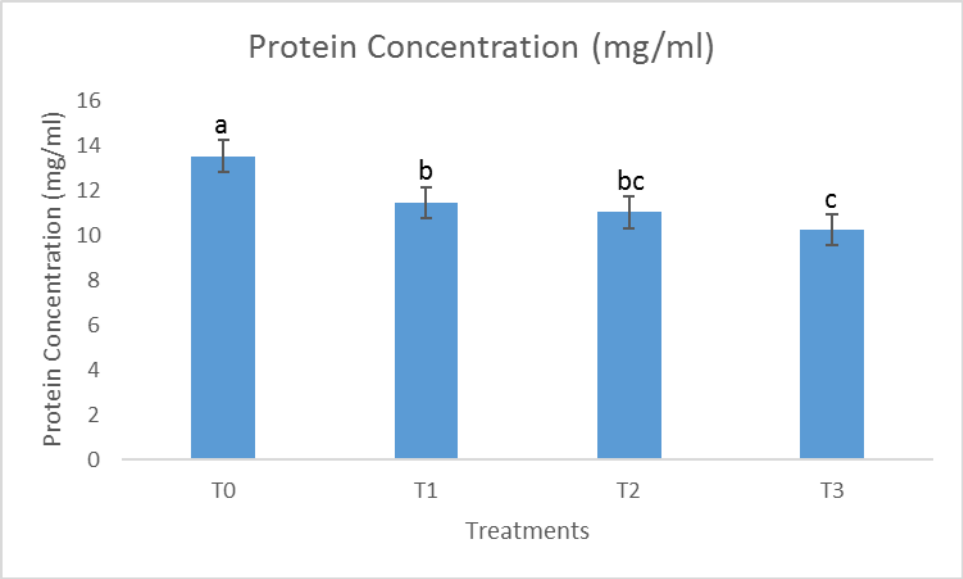

Figure 1: Effect of glyphosate herbicide on the protein concentration of groundnut (*Arachis hypogaea*).

Figure 1 shows the effect of the glyphosate herbicide on the protein concentration of *Arachis hypogaea*. The result shows that protein concentration decreases with increasing application rate of glyphosate herbicide. Significant difference is observed to occur among all the treatments. The highest mean value occur in the control (13.53mg/ml), followed by T_1 (11.45mg/ml) as the second highest. The lowest mean value occur in the plot with the highest glyphosate application rate (10.24mg/ml). T_1 and T_2 are seen to be statistically similar and likewise, T_2 and T_3 are also observed to be statistically similar to each other. This implies that the glyphosate herbicide inhibited the normal protein synthesis and this is in line with the work of Hoagland and Duke (2002) which states that glyphosate's main effect is to block an enzyme that plants need to make amino acids and protein.

Conclusion

The treatment that was weeded manually (T_0) shows difference from the other treatments. In term of plant height and stem girth, the effect of the applied herbicide was noticed when compared with the control. The result from the leaf count however did not show any difference between the control and treatment T_1, although, differences were observed between the control and T_2 and T_3. The yield parameters also shows that differences occur between the control and the other treatments when observing the number of flowers and the yield. Glyphosate effect also show in the result of the protein concentration. Based on these results, glyphosate application at these could have an impact on the growth and yield parameters as well as protein concentration of groundnut. Further research is encouraged to be conducted especially on the effect of glyphosate on the constituent amino acids that are found in groundnut.

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