Proper Timing Of Chemical Weed Control And Fertilizer Application Enhances Maize Growth And Yield Across Northern Ghana: A Review

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ABSTRACT

Maize is an important food crop in the world. Among the challenges affecting its production, weeds infestations and soil infertility play dominant roles across northern Ghana. Though several methods have been employed to manage these problems, the current average yield of 1.5 t/ha is far below the achievable yield of 5 t/ha. With the numerous work done on the incorporation of these management inputs in modern agriculture, this review identifies improper application of the inputs relative to the growth stages of the maize crop as an obstacle to attaining the desired yield. Much more marginal value in yield could be realized with the proper timing of the inputs in the maize production

Keywords: Fertilizer application, Chemical Weed Control, Timing, Maize Growth, Maize Yield

1. INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop grown throughout the world (Kwaga, 2014; Larbi, 2013; Khan et al., 2003). The crop is grown in all the ecological zones of Ghana. It is used as food for people and also serves as the main foodstuff for poultry and livestock (Asenso-Okyere, 2001; Larbi et al., 2013). These characteristics of the crop have made it a valuable dietary and an industrial crop in the world (Bibi *et al*., 2010, Gunaratna *et al*., 2010). With the anticipation to overcoming food and nutritional insecurity in the world, maize is among other crops considered significant to achieve this goal (Lutz *et al*., 2001).

The population of the world is anticipated to reach eight billion by 2025, which would put the already scarce arable land under considerable agronomic pressure. Not only would the land be more scarce, but also would be losing fertility due to the continuity of farming activities on the same piece of land for a long period as well as the emergence of different weed biodiversity on the cultivated arable lands (Kolářová et al., 2013).

Maize production involves the application of several production factors; including land, seed, soil fertility management and weed control. When good seeds are selected for planting, the infestation by weeds and poor soil fertility management are the most paramount factors involved in the reduction of the crop's yield (Khan *et a*l., 2003). Yield loss due to weed infestation of up to 39.5% has been reported in maize (Oudejans, 1991). The output of the cultivated maize depends to a larger extent on the correlated effects of these inputs in the field and on the growth stages of the crop (Tadesse et al., 2013; Havlin et al., 2005). In recent times, the incidences of weed infestations and poor soil fertility managements have taken a central position in the production of maize (Tadesse et al., 2013; Khan et al., 2003). Even though good seed ultimately determines the potential yield of the maize, it is the management of the weeds and soil fertility that actually gives the actual yield of the maize variety in context (Kwaga, 2014; Havlin et al., 2005).

Despite the significance and demand of maize in the global food and nutritional security, there is still the feasibility to increase per unit yield due to large gaps between potential and actual yield per hectare (Khan *et al*., 2003). The average yield of maize in recent times is 1.5 t/ha, which falls below the achievable yield of 5 t/ha (Asenso-Okyere, 2001). The low actual maize yield notwithstanding, current changes in global environmental phenomena; and the related challenges posed on the agricultural environment: such as declining soil fertility, prolific emergence of weed species, drought and environmental pollutions (Anselm and Taofeeq, 2010), necessitate the need for pragmatic application of these inputs for their ultimate effect on maize production.

Several methods are available for the achievement of efficient weed and soil fertility managements in maize production (Begna *et al*., 2001). For all these methods, there is the need for timely application of the input parameter (Abouzienena *et al*., 2008).

Weeds are unwanted plants growing out of place in a particular time at a given location and interfering with the human operations in the cultivated field as well as the yield of the cultivated crop. Weeds compete with the maize plant for growth resources such as nutrients, which posses a vital functioning role for the growth of the maize plant (Mendelsohn et al., 2006). Weeds are classified into several categories with different forms of adaptation and damaging ability. The criticality of weed interference in maize production is influenced by the competing weed species, the cultivar of maize, plant density and environmental factors such as light, water, nutrients and allelopathy (Poku and Akubundu, 1985). Cultural, biological and chemical control methods are the most popular means of management of weeds in maize fields. Despite the popularity, the most frequently used in Ghana are the cultural and the chemical control methods. In recent agricultural activities, however, the chemical method of weed control is becoming the ultimate weed management strategy (Larbi *et al*., 2013).

To control weeds, herbicides are formulated in different types and forms, based on the target weed species at a particular growth stage of the maize crop. Whiles some herbicides are non-selective and may kill all plants, some are selective as post-emergence or pre-emergence herbicides (Mendelsohn et al., 2006; Poku and Akubundu, 1985). Even though the nomenclature of the categories clearly defines the time they should be applied in the field, most farmers still miss these recommendations. Instead, the herbicides are applied in blanket recommendations either in their own way or using the recommendations of the manufacturers, but untimely. These normally result in an ineffective control of the weeds, which sometimes result in an environmental pollution and chemical wastage leading to an inflated cost of production (Green et al., 1987; Gianessi and Reigner, 2007).

The productivity of the maize crop depends, largely on the available nutrients to the crop (Tadesse et al., 2013; Larbi et al., 2013). The fact that an economic yield of the crop is being realized means that some nutrients from the soil have been consumed (Tadesse et al., 2013). With the limited land size for recent

farming activities, pieces of land are being put under continuous cultivation for long periods, and as a result leave the land in an infertile state (Ajeye, 2014). Since maize is a heavy feeder, soil infertility has become a serious issue in maize production. In view of this, organic and inorganic soil fertility strategies have been employed over the years to manage soil infertility in maize production (Tadesse et al., 2013; Havlin et al., 2005). Though the inorganic soil fertility method is frequently used, most farmers across northern Ghana use the organic option more frequently. With regards to time of application, the inorganic fertilizers are applied in twofold: basal application and/ or top-dressing. Basal application is done at the active merismatic stage of the maize plant while the top-dressing is done towards the crop maturity stage (Thompson et al., 2014; Tadesse et al., 2013). In these regards, some farmers prefer that basal application are done at one week after germination, while others opt for two weeks after the crop's germination. In another school of thought, some agronomists still hold the argument that it should be applied at planting. T his controversy of timing of basal application of NPK thus requires an enhanced study to investigate the economical justification of a chosen decision.

This review paper is therefore geared towards discussing possible ways by which the fertilizer and chemical weed control inputs could be applied to ensure maximum marginal return in maize production, with much emphasis on the timing of application relative to the anticipated changes in climatic variables (Kugbe et al., 2012).

2. MAIZE VALUE CHAIN AND IMPORTANCE

Maize is an important cereal crop in the world. It plays a major role in the global food basket since it is the third most important food crop in the world after rice and wheat (Bibi et al., 2010). In recent times its production has seen a greater attention in relation to the processes involved. In the past, maize producers were only interested in the ultimate economic grains. Agronomic practices were therefore geared toward seeing the maize plant bear cobs; while producer have to wait for it to get dried and harvested. In modern agriculture, the ultimate economic yield of the maize plant is planned and determined, starting from the selection of seed through land preparation, ploughing, planting, weed and fertility management, harvesting, processing and marketing. These planned value chain production processes have become necessary in the sense that several uses have been found to be associated with the crop starting from the roots through the shoot and to the most economic part, the grains. The maize stalks are used as an alternative energy source for home cooking. It is also use as animal feed during the dry season in the tropics. Maize in recent times is also seen as an alternative for biogas production in the world. Maize grains contain 15% protein, 20% carbohydrates and other macro and micro nutrients for human consumption.

3. CLIMATE CHANGE AND CHEMICAL WEED CONTROL IN MAIZE

The climate of a region, coupled with the subsequent changes in climatic parameters over the years determines the cultivar of maize to be cultivated in specific geographic and ecological zones across the world. But for the erratic climatic pattern and the associated effects of drought, windstorms, limited rain water supply, prolific increases in weed biodiversity, global warming and soil degradation (Kala *et al*., 2012), plant breeders, agronomists and soil scientists would not have put up efforts to ensure ecological balances in the production of maize species to enhance food productivity.

Weeds infestation in maize has been one of the significant yield reduction factors (Oudejans, 1991). Weeds have wide range of adaptability and thus are better colonizers in the maize field in an era of changes in climatic variables. The inception of any changes in climatic and environmental variables strengthens the relative adaptability and stability of such better adapted weed species over the cultivated and more susceptible maize crop (Mendelsohn et al., 2006). Efficient and more effective weed control methods are therefore needed to tackle this colonizing ability of the weeds to enhance good maize productivity.

Chemical weed control has been found to offer this efficiency and effectiveness since the weeds could be managed even before they emerge (Green et al., 1987). Across northern Ghana, glyphosates are used for land preparation and for pre-emergence weed control in maize production (Larbi et al., 2013; Green et al., 1987). Hand hoeing though still in use for the control of weeds in modern farming, the chemicals are more systemic and persistence; thus resulting in an effective, efficient and longer period of weed control (Ali et al., 2003). On the other hand, the rate at which weeds emerge from hand weeded fields is comparatively rapid that farmers are now into frequent use of the chemical control method (Finney, 1988). However, the recommended time of application is not always adhered to and thus leading to environmental pollution, inflated cost of production, inefficient weed control with the consequent reduction in maize yield (Tadesse et al., 2013; Havlin et al., 2005).

4. CHEMICAL WEED CONTROL IN MAIZE

4.1 TOTAL AND PRE-EMERGENT HERBICIDES

Maize is a heavy feeder (Muthukumar et al., 2007; Gehl et al., 2005). The available nutrients in the soil should be managed in such a way that the already limited nutrients are not shared with any weed species (Havlin et al., 2005). This can only be achieved through the use of herbicides. The non-selective general post-emergence weedicides, normally glyphosates are used for this purpose during land preparation. Ideally, weeds that are already in the selected site should be killed before ploughing (Green et al., 1987; Gianessi and Reigner, 2007). Not only does this makes the ploughed land nice for planting activities but also helps in maintaining the soil structure and fertility through the retention of the weed's nutrients on the field. Pre-

emergent herbicides also serve this purpose. They are applied at planting of the maize plant. This puts control on the weed seed bank thus allowing the available nutrients to be utilized in a vigorous germination and subsequent plant growth. Some of the frequently used total and pre-emergent herbicides in maize are glyphosates, terbutryn, Metachlor and to some extent pendimethalin. However, reports have shown that the use of pendimethalin in maize is not advisable due to the initial growth retardation reaction it gives to the maize plant.

4.2 POST-EMERGENT HERBICIDES

Post-emergent herbicides are applied on the field after the weeds are emerged. They are selective. The most popular of this category for the maize crop are 2, 4-D and nicosulfuron. In order to have an effective weed control with post-emergent herbicide, the application time should be at the early stages of the weeds growth (Knenzevic *et al*., 2003). Across Ghana, however, most farmers apply this herbicide at any growth stage of the weed, which should be discouraged as this practice makes the chemical ineffective. Besides, late application allows the weeds to compete with the crop for the available nutrients before control (Amaregouda et al., 2013).

4.3 MERITS OF HERBICIDE USAGE IN MAIZE PRODUCTION

Apart from competing with the cultivated maize for water, nutrients, light and space, weeds also serve as alternative host to plant diseases and insects (Poku and Akubundu, 1985). With the efficient control with herbicides, the plant gets, without competition, free access to water, nutrients, light and space. The incidence of pests and diseases are also reduced as the alternative hosts to such vectors are eliminated (Hussain *et al*., 2003). Herbicides also have in their structural component, some nutrient elements such as nitrogen, potassium and phosphorus that the maize crop can utilize (Gianessi and Reigner, 2007). The breakdown of these chemicals therefore increases the availability of these elements for the healthy growth of the plant. Herbicides have shown to control weeds in maize more efficiently than any other weed control method (Ali *et al*., 2003). This is attributed to its chemical composition, its persistence on the treated weed species and the systemic ability (Hussain et al., 2003). Whiles other methods of weed control, e.g., hand weeding, only cuts the shoots to the soil surface and allows for re-growth in short intervals, the systemic ability of some weedicides enable them to comparatively kill the treated weeds from the shoots down to the roots (Knenevic *et al*., 2003).

4.4 HERBICIDE APPLICATION

Herbicides are applied to the target weed either on the soil or as foliar (Larbi *et al*., 2013). Knap sac and boom sprayers are the commonest machines used for herbicide applications, keeping in mind the application rate (Aamil et al., 2002). Even with this, the best time for the application is still a controversy. Whilst others are recommending that the application should be done on a sufficiently moist soil, some other scientists say that soil moisture has no significant effect on its action. It is a common knowledge, however, that the

recommended time for insecticide application is either in the morning or evening (Fairbrother et al., 2014). This has not been well established for the different herbicides used. However, the driving forces for herbicide breakdown are moisture, wind, sunlight and the application accuracy (Knezevic *et al*., 2003). Nonetheless paramount among them are the moisture and the discharging perfectness of the chemical onto the treated surface (Larbi *et al*., 2013; Aamil et al., 2002).

5. FERTILIZER INCORPORATION IN MAIZE PRODUCTION

Fertilizers are artificially formulated plant nutrient elements intended to be supplemented onto the growth medium to augment the fertility ability of the medium (Gehl et al., 2005; Muthukumar et al., 2007; Stewart et al., 2005). The most popular medium, especially on a larger scale of maize production is the soil. With the current pressure on arable land, optimal maize productivity would solely be achieved through the use of improved farming technologies. Soil infertility is eventually one of the negative results of the current arable land pressure (Ajeye, 2014). Available lands are continually being put under cultivation with little or no fallow, necessitating the need for an external nutrient input (Havlin et al., 2005). Though several soil fertility strategies have been developed over the past years including the use of organics, inorganic and cultural strategies (Kwaga, 2014), the use of inorganic soil fertility management is the dominant form of fertility management in maize production (Kwaga, 2014; Havlin et al., 2005). In the northern region of Ghana, it has been extensively adopted in maize production.

5.1 FERTILIZER APPLICATION METHODS

Several methods exist for fertilizer application in the maize field. Methods such as drenching, dibbling and broadcasting are mostly used depending on the fertilizer type, the soil physical and chemical properties, and the time of application (Tadesse et al., 2013; Havlin et al., 2005). Surface placement, ring and application by dibbling are recommended for maize fields (Kwaga, 2014). Under the current declining status of most soils and the increasing uncertainty in climatic variables, dibbling and the burial of fertilizers are recommended to decrease surface losses due to volatilization and erosion. Though fertilizer incorporation has been numerously found to decrease losses and enhance nutrient use efficiency (Ali et al., 2011), the exact time of the application remains in variable among farmers in the ecology (Kwaga, 2014).

5.2 TIME OF FERTILIZER APPLICATION

The intent of fertilizer incorporation in maize production is to augment the nutrient status of the soil to enhance its supplying power to the growing plant (Havlin et al., 2005). Physiologically, the growth of the maize plant is partitioned into stages, each stage having peculiar nutrient requirements for optimal growth (Muthukumar et al., 2007; Gehl et al., 2005). The meristematic, elongation and maturity stages need the supply of specific nutrients for enhanced growth and yield (Muthukumar et al., 2007). Nonetheless, fertilizers

are mostly applied by farmers in a blanket recommendation on the recommended time of application. There is therefore the need to inculcate the habit of adequate fertilizer type and precise timing into farmers. Since this gap of knowledge contributes to fertilizer use inefficiency and thus inflate cost of production, more studies should be done to maximize the marginal return on fertilizer incorporation in maize productivity.

6. CONCLUSION

In order to enhance maize growth and increase its yield per unit area of cultivated land, the forgoing indicates that chemical weed control and appropriate fertilizer application, in terms of rate, and time of application are essential inputs in its production. For weed control, both pre-emergence and post emergence herbicides should be used to completely reduce the impact of weeds on yield. For fertilizer application, basal application; either at planting, one week after planting or two weeks after planting; followed by a top dress with nitrogen when the crop is about knee high are recorded to currently give the maximum maize yield on farms across northern Ghana. The uncertainties associated with an anticipated change in climatic variables and its impact on maize growth and development across the region should, however, necessitate studies on impacts of various climatic scenarios on maize yield at optimum fertilization and weed control.

7. REFERENCES

Aamil, M., Zaid, A. and Khan, M.S. (2002) Effect of herbicide dose rate on growth, nodulation and yield in chickpea (Cices arietinum L). Annals of Applied Biology 23: 8-9.

Abouzienena, H.I, I.M.El-Metwally, E.R.El-Desoki. (2008). Effect of plant spacing and weed control treatments on maize yield assesement and associated weeds in sandy soils. American Eurasian Journal of Agricultural and Evironmental Science 4(1): 9-17.

Ajeye, D.B. (20014). Restoration of Degraded Gidan Waya Forest Reserve, Academic Journal of Interdisciplinary Studies 3 (7). 146-152. Doi:10.5901/ajis.2014.v3n7p146

Ali, K., F.Munsif, M. Zubair, Z. Hussain, M. Shahid, I.U.Din and N.Khan, 2011: Management of organic and inorganic Nitrogen for different Maize varieties. Sahad Journal of Agriculture 27(4): 525-529.

Ali, R.,S. K. Khalil, S. M. Raza and H. Khan.(2003). Effect of herbicides and row spacing on maize (*Zea mays*). Pakistan Journal of Weed Science Research 9 (3-4): 171-178.

Amaregouda, A., Jitendra, J., Chetti, M.B., Nawalagatti. (2013). Effect of Weedicides on Physiological parameters, Growth, Yield and Yield components of Soybean (*Glycine max* L.) and Weed Growth. Research and Reviews: Journal of Agriculture and Allied Sciences 2 (4): 12-15

Anselm, A.E., Taofeeq, A.A. 2010. Challenges of agricultural adaptation to climate change in Nigeria: a synthesis from the literature. Field Actions Science Reports 4. URL :http://factsreports.revues.org/678

Asenso-Okyere K. (2001). Transforming Agricultural Production and Productivity for sustained rapid growth and Development. Ghana in the 21st Century. ISSER Millennium Semina Series No. 4. Institute of Statistical, Social and Economic Research, Unversity of Ghana

Begna, H.S., R.I.Hamilton, L. Assemat, K. Foroutanpour and D.L. Smith. (2001). Morphology and yield response to weeds pressure by corn hybrids differing in canopy architecture. Eurasian Journal of Agronomy 14 (4): 295-202.

Bibi, Z., N. Khan, M. Akran, Q. Khan, M.J. Khan, S. Batool and K.Makhdum. (2010). Integrating cultivars with reduced chemical rates for weed management in maize. Pakistan Journal of Botany 42 (3): 1923-1929.

Fairbrother, A., Purdy, J., Anderson, T., Fell, R. (2014). Risks of neonicotinoid insecticides to honeybees. Environmental Toxicology and Chemistry 33 (4); 719-731. DOI: 10.1002/etc.2527 fertilizers: An introduction to Nutrient management. Pearson Education Incorporation, upper Saddle River, New Jersey.

Finney J.R., 1998. World crop protection prospects: dimisting the crystal ball. In. The Bawnden Memorial Lectures: Silver Jubilee Edition. Lewis T (Ed). Brighton Crop Protection Conference- Pest and Diseases 1:3-14

Gehl RJ, Schmidt JP, Maddux LD, Gordon WB (2005). Corn yield response to nitrogen rate and timing in sandy irrigated soils. Agronomy Journal 97. 1230-1238.

Gianessi, L. and N. Reigner. 2007. The Value of Herbicides in U.S. Crop Production. Weed Technology 21:559-566.

Green M.B., G.S.Hartley and T.F. West (1987). Chemicals for Crop Improvement and Pest Management. 3rd edition. Pergamon, Oxford.U.K. 370pp

Gunaratna, N.S., Groote, H.D., Nestel, P., Pixley, K.V., McCabe, G.P. (2010). A meta-analysis of community-based studies on quality protein maize. *Food Policy 35: 202--10.*

Havlin, J. L., S. L. Tisdale, W. L. Nelson, and J. D. Beaton. 2005. Soil fertility and Growth and Yield of Wheat (Triticum aestivum). International Journal of Agriculture and Biology 5 (2): 166-168.

Hussain, N., Khan M.B., Tariq M, Hanif S. 2003. Spectrum of Activity of Different Herbicides on Growth and Yield of Wheat (*Triticum aestivum*). International Journal of Agriculture and Biology 5 (2):166-168.

Kala N, P Kurukulasuriya, R Mendelsohn (2012). The impact of climate change on agro-ecological zones: evidence from Africa." *Environment and Development Economics* 17: 663-687. DOI: 10.1017/S1355770X12000241

Khan MA, Marwat KB, Khan N, Khan IA, 2003. Efficacy of different herbicides on the yield and yield components of maize. Asian J Plant Sci, 2:300-304.

Knezevic M., Durkic M., Knezevic I.,Loncaric Z.(2003). Effects of pre- and post- emergence weed control on weed population and maize in different tillage systems. Plant Soil Environment, 49:223-229.

Kolářová, M., Tyšer, L., Soukup, J. (2013). Diversity of current weed vegetation on arable land in selected areas of the Czech Republic. Plant Soil Environment 59 (5): 208-213.

Kugbe JX, Fosu M, Tamene LD, Denich M, Vlek PLG (2012) Annual vegetation burns across the northern savanna region of Ghana: period of occurrence, area burns, nutrient losses and emissions. Nutrint Cycling in Agroecosystems 93 (3): 265-284. DOI 10.1007/s10705-012-9514-0

Kwaga, Y. M. 2014: Effect of Timing of Nitrogen Application on the Performance of Maize (Zea mays L) Varieties at MUBI, Northern Guinea Savanna of Nigerial. American Journal of Research Communication 2 (2): 71-81.

Larbi E, Ofosu Anim J, Norman JC, Anim-Okyere S, Danso F. 2013. Growth and yield of maize (Zea mays L.) in response to herbicide application in the coastal savannah ecozone of Ghana. Net Journal of Agricultural Science1(3),81-86p.

Lutz, W., Sanderson, W., Scherbov, S. (2001). The end of world population growth. *Nature* 412:543–5

Mendelsohn, R., A. Dinar, and L. Williams. "The Distributional Impact of Climate Change On Rich and Poor Countries." *Environment and Development Economics* 11.2 (2006): 159-178. DOI: doi:10.1017/S1355770X05002755

Muthukumar VB, Velayudham K, Thavaprakaash N (2007). Plant Growth Regulators and Split Application of Nitrogen Improves the Quality Parameters and Green Cob Yield of Baby Corn (*Zea mays* L.). Journal of Agronomy 6 (1): 2008-2011.

Oudejans JH, 1991. Agro-pesticides: properties and functions in integrated crop protection. United Nations Economic and social commission for Asia and the Pacific. United Nations.

Poku JA, Akobundu IO, 1985. Weed Management designed for smallholding. In Cowpea Research Production, (ed) Singh SR. and Rachie KO John Willey and Sons Ltd.

Stewart, W.M., Dibb, D.W., Johnston, A.E. and Smyth, T.J. 2005. The contribution of commercial fertilizer nutrients to food production. *Agronomy Journal 97: 1-6.*

Tadesse, T., Assefa, A., Liben, M., Tadesse, Z. (2013). The effect of nitrogen fertilizer split application on the nitrogen use efficiency, grain yield and economic benefit of maize production. International Journal of Agricultural Science 3 (5); 493-499.

Thompson, A.M., Crants, J., Schnable, P.S., Yu, J., Timmermans, M.C.P., Springer, N.M.,Scanlon, M.J., Muehlbauer, J.M. (2014) Genetic control of maize shoot apical meristem architecture. G3: Genes, Genomes, Genetics Mission . doi:10.1534/g3.114.011940