Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

Effects of Phosphorus on the Phenological Traits of Maize (Zea Mays) in Yola North Eastern Nigeria.

[1]Kwaghe, E.J. and [2]Gungula, D

[1] Raw Materials Research and Development Council, Abuja, Nigeria

[2] Department of Crop Production and Horticulture, Federal University of Technology, Yola

ARTICLE INFO

Article history:
Received November 18, 2023
Received in revised form December 16, 2023
Accepted December 23, 2023
Available online January 21, 2024

Keywords:

Phosphorus
Tasselling
Anthesis
Silking
Maturity
maize

Corresponding Author's E-mail Address:
e-mail: ekwaghe16@gmail.com
https://doi.org/10.36265.njss.2023.330112
ISSN– Online **2736-1411**
Print **2736-142X**

ABSTRACT

This study was conducted during the 2000 and 2001 cropping seasons at the University Research Farm, Federal Universality of Technology, Yola to evaluate the effects of phosphorus on the phenological traits of maize (New Kaduna White) hybrid variety. There were eight treatments consisting of four levels of N; 0, 60, 120 and 180kgNha^{-1} and two levels of P, 0 and 60kgPha^{-1}, replicated three times. The study was a factorial type fitted in a Randomized Complete Block Design (RCBD). Phenological data collected were number of days to 50% tasselling, anthesis, silking and physiological maturity during the two cropping seasons. The study showed highly significant ($P \leq 0.01$) decreases in days to 50% tasselling, anthesis, silking and maturity for the 2000 and 2001 cropping seasons with the sole application of 60kgP^{-1}. Furthermore, the mean performance of phenological parameters showed the shortest days to silking with the combined application of 120kgNha^{1} and 60kgPkgha^{-1}, indicating that P application is critical for maize to show early phenological traits.

1.0 Introduction

Maize ranks third in world's cereals after wheat and rice (Imran 2015). It is a short duration crop capable of producing large quantity of food grain. Among all the crop plants, maize is the most versatile one as it has great nutritive value; 72% starch, 10% protein, 4.8% 8.5% fibre, 3 % sugar and 17% ash (Chaudery, 1983). Of the three major developing regions of the world, Africa is the only one in which the index per capita food production has declined steadily during the last decade. Unless the present trend is reversed, 25 to 30 years from now, Africa will have the world's largest deficit in cereals both in absolute and relative terms the challenges facing African agriculture in the next 20 years are immense, as the prospects of importing food to offset these deficits are not economically feasible.

To meet these challenges will require drastic increases in productivity of the principal staples of the continent through any well-articulated research and development. Maize more than any crop offers the promise of meeting Africa's food needs as no other cereals can be used in many ways as maize (RMRDC, 2004). Maize (*Zea mays*) is a member of the grass family poacea to which all cereals belong. Also called corn, in the USA, is a monoceaous plant which bears female organs, the pistil in separate flowers and same plant. The male inflorescence is commonly referred to as tassel occupying the terminal position on the main axis (Kochler. 1986). The silk of the female flower develops from the growing point of the flower. It elongates through the length of the husks propelled by the growth of an intercalary husks propelled by the growth of an intercalary main stem located at the base. Eachsilk continues to grow until it is pollinated and fertilization takes place (Duncan, 1975).

Seasonal fluctuations in annual rainfall has made it difficult to achieve optimum yield of annual crops such as maize, either due to poor germination when rain ceases for some time after the initial onset or when the rain ceases before the completion of vegetation growth. However, the seed of improved variety and fertilizer are the main factors in enhancing the output of maize (Dowswell, et al., 1996). The soils in the study area are deficient in phosphorus and are alkaline, thus such soils have higher phosphorus fixation capacity and therefore higher demand for phosphorus (Hussein and Haqq, 2000). According to (Onasanya et al., 2009), appropriate type of fertilizer can increase the yield by 50 %. Phosphorus deficiency, therefore, is invariably a common crop growth and yield limiting factor in unfertilized especially in soils high in calcium carbonate which reduces p solubility (Ibrikei et al. 2005)

Phosphorus plays an indispensable role as a universal fuel for all biochemical activity in living cells and also plays a significant role in the breakdown of carbohydrates or other food products by photosynthesis in plants, which is usually supplied in the form of ATP. Other important role of phosphorus is in the stimulation of early maturity (Miller and Donahue, (990). Mallarino et al. (1999) confirmed this when they reported that soil phosphorus availability during maize seedling development is critical for early growth and development of maize. Phosphorus can significantly increase vegetative growth and grain yield (Reghurum et al., 2000) as it plays many roles in many physiological processes that occur within a developing and maturing plant and is involved in enzymatic reactions in the plant.

According to Ibrahim and Kandi, (2007) and Amnanullah et al., (2009a, large quantities of phosphorus is found in seed, and it is considered essential for seed formation, inflorescence, grain formation, ripening and reproductive parts of maize plant, therefore, phosphorus in adequate amount is necessary for earlier maturity, rapid growth and improves the quality of vegetative growth and grain development in maize production. Phosphorus is essential in cell division because it is a constituent of element of nucleo proteins which are involved in the cell reproduction process (Imran 2015).

The objectives of this study were to evaluate the effects of phosphorus (P) on phenological traits of maize (zea mays L.) in Yola, North-Eastern Nigeria, and to make recommendations based on the results of the study to farmers in Yola and environs.

2.0 Materials and Methods

2.1 Description of the study area

The field experiments were located at the Research and Teaching Farm of the Department of Crop Production and Horticulture, Faculty of Agriculture, Federal University of Technology Yola. Yola located in the Northern Guinea Savannah ecological zone of Nigeria within latitude 9^0 19N and longitude $12^0$30E at an altitude of 185.9m above sea levels (Bashir, 2000). The area had a total rainfall of 745.5 mm and 690 mm in 2000 and 2001 cropping season. A total of 745.5 mm and 618.4 mm of rainfall were recorded during the crop life cycle of maize in 2000 and 2001 of rainfall were respectively (Table 1a and 1b). Rainfall was distributed over 150 and 160 days and can effectively support high maize production. Yola and its environment have high solar radiation which indicated high photosynthetic potentials for crops like maize that are C4 and require warm temperature.

2.2 Experiment design and treatment

The experimental design was a randomized complete block design (RCBD) with three replications during both the 2000 and 2001 cropping seasons. The treatments were 4 levels of nitrogen, and 2 levels of phosphorus which were factorially arranged resulting in 24 treatments. The levels of nitrogen (hereafter designated as N) were 0, 60,120 and 180 kgN ha^{-1} and phosphorus (hereafter designated as P) levels were 0 and 60 kgP^{-1}. The total land area from the experiment was 430.5 m^2which were demarcated and labelled into small plots of 10.5m^2 each made up of 3m x 3.5m. Each plot was demarcated into 5 rows with each row consisting of 12 hills. Composite soil samples were taken from each plot bulked, labelled, air dried in the shade and was taken to the laboratory to analyse for physicochemical properties. Particle size distribution was determined following the Walkey and Black method of chromic acid wet oxidation method (Nelson and Sommers, 1996). Total N was determined by the macro-kjedal digestion method (Bremmer, 1996); available P was determined using the bicarbonate method (Olsen et al. 1985). Soil exchangeable cations (Na^+, K^+, Ca^{2+} and Mg^{2+}), were extracted with IN NH_4 Acetate solution, but while Na^+ and K^+ were determined using the flame photometer, C^{2+} and Mg^{2+} were determined by titration with 0.02 N EDTA solution (Page et al. 1982).

2.3 Agronomic Practices

A popular maize hybrid variety, New Kaduna White sourced from Premier Seeds Kaduna was used for the experiment. Planting was done in early July for the two cropping seasons. The spacing between rows was 75 cm while the spacing within rows was 25 cm which gave a plant population of 53,333.33 plants per hectare. Basal application of 60$kgPha^{-1}$ was applied at planting in all the plots except for the control where no P was applied. N fertilizer was applied in two split doses. 30 $kgPha^{-1}$at planting while the remaining 30 $kgPha^{-1}$ was applied four weeks later. Weed control was done using a mixture of Atrazine and Garamazone herbicides which was supplemented with manual weeding as the field was removed.

2.4 Data Collection

Data on soil nutrient status, growth and phenological parameters were collected. Phenological parameters measured include days to 50% tasselling, anthesis, silking and maturity. All data were subjected to analysis of variance (ANOVA) using Statistical Analysis Software (SAS, 2002). The difference among significant treatment means were tested using least significant difference (LSD) at 5% level of significance.

3.0 results and Discussions

The meteorological information of the trial site for the 2000 and 2001 season is given in Tables 1a and 1b. Allaby (1998) reported that the factors of weather that affect growth and development of maize are temperature, rainfall, amount of sunshine and relative humidity. The total rainfall in Yola during the 2000 cropping season was 775.45 mm as against 690.00 mm for the 2001 cropping season. This was considered sufficient for optimum maize production. It is mostly reported that maize is sensitive to drought stress during pollination when delayed emergence of silk may reduce fertilization (Jones, 1985). Drought stress as late as two to three weeks following 50% silking may also seed number (Frey, 1981). Similarly, temperature which is very important for phenological development and other physiological

processes during growth and development of the crop were found to vary during the 2000 and 2001 cropping seasons. The maximum temperature during the month of June, July and August, which was 38.8^{0}C for year 2000 and 35.9^{0}C for year 2001 was sufficient to hasten flowering and ear development.

The physical and chemical properties of the experimental sites are presented in Table 2. The results showed that the soils ranged from slightly acidic to moderately acidic sandy loam with an average of 67% sand, 20% silt and 13% clay. The soils were therefore generally coarse textured and well drained, characteristically low in org. C (0.74%), Avail. P (1.25 mgkg^{-1}), exchangeable bases (0.61 cmolkg^{-1}) and CEC (2.81 cmolkg^{-1}).

Table 1a: Weather information during the 2000 cropping season in Federal University of Technology, Yola

Month	SRAD (hrs/day)	T MAX ^{0}C	T MIN ^{0}C	RAINFALL (mm)
Jan	5.6	55.6	21.3	0.00
Feb	6.6	34.3	21.1	0.00
March	11.1	40.6	25.3	0.00
April	9.5	41.1	23.8	4.75
May	7.5	37.8	26.1	99.9
June	8.2	31.9	24.4	115.1
July	8.1	31.0	23.7	122.7
August	6.1	38.8	23.0	248.4
September	6.6	31.8	23.1	155.1
October	7.4	34.6	23.4	29.5
November	7.8	38.0	20.2	0.00
December	5.1	34.5	18.3	0.00
TOTAL	89.3	430	273.8	775.45

SRAD = Solar radiation; T MAX ^{0}C = Maximum Temperature; T MIN ^{0}C = Minimum Temperature

Table 1b: Weather information during the 2001 cropping season at Federal University of Technology Yola

Month	SRAD (hrs/day)	T MAX ^{0}C	T MIN ^{0}C	RAINFALL (mm)
Jan	6.4	35.3	19.0	0.00
Feb	7.0	36.3	22.0	0.00
March	10.2	41.5	26.1	0.00
April	8.2	40.1	27.3	57.4
May	8.9	38.9	26.8	122.2
June	7.9	35.9	26.5	103.1
July	6.9	31.0	23.8	155.2
August	6.0	29.8	22.4	106.7
September	7.2	31.3	22.4	131.2
October	18.2	31.6	20.0	14.2
November	7.7	36.0	19.5	0.00
December	5.8	35.0	19.5	0.00
TOTAL	90.4	422.7	237	690

SRAD = Solar radiation; T MAX ^{0}C = Maximum Temperature; T MIN ^{0}C = Minimum Temperature

Table 2: Physicochemical properties of the soils of the experimental site for the 2000 and 2001 cropping seasons

Soil characteristics	Values for year 2000	Values for year 2001
Sand (%)	65	69
Silt (%)	21	19
Clay (%)	14	12
Soil texture	Sandy loam	sandy loam
Soil pH in H_2O	6.27	6.38
Organic carbon (%)	0.54	0.40
Total N (%)	0.06	0.08
Available P ($mgkg^{-1}$)	0.8	0.9
Exchangeable Na^+ ($cmolkg^{-1}$)	0.28	0.32
Exchangeable K^+ ($cmolkg^{-1}$)	0.28	0.37
Exchangeable Mg^{2+} ($cmolkg^{-1}$)	0.41	0.62
Exchangeable Ca^{2+} ($cmolkg^{-1}$)	0.33	0.46
CEC ($cmolkg^{-1}$)	2.76	2.85

CEC = Cation exchange capacity; P =phosphorus; Na = Sodium; K = Potassium; Mg = Magnesium; Ca = Calcium

Source: Soil Science Laboratory, Federal University of Technology, Yola

During the 2000 cropping season, highly significant differences among means ($P \leq 0.01$) were observed due to P treatments for days to 50% tasseling, anthesis, and maturity. However, days to 50 % silking showed significant differences among means ($P \leq 0.05$), due to P treatment during the same cropping season (Table 3a). During the 2001 cropping season, highly significant differences among means ($P \leq 0.01$) were observed for all the phenological traits measured (days to 50% tasseling, anthesis, silking and maturity) due to P treatments (Table 3b).

Furthermore, for both the 2000 and 2001 cropping seasons, the mean performances of all the phenological traits observed showed significant reduction in days to 50% tasselling, anthesis, silking and physiological maturity (Tables 4a and 4b). These significant reduction in days observed in all the phenological traits for the two cropping seasons could be attributed to the indispensable role played by P in its many compounds in cell stimulation and hastening of maturity. This is consistent with the reports by Miller and Donahue (1990) and Mallarino et al., (1999) who reported that P plays an indispensable role as a universal fuel for all biological activity in living cells, which is critical to early growth and development of maize.

Table 3a: Analysis of variance Table showing the mean squares of phonological parameters of maize measured during the 2000 cropping seasons

Source of variations	d.f.	Days to 50% tasselling	Days to 50% anthesis	Days to 50% silking	Days to 50% maturity
Replication	3	0.6667	0.1667	2.042	4.29
N	3	0.5000^{ns}	1.8194^{**}	1.042^{ns}	3.92^{ns}
P	1	20.16678^{**}	18.3750^{**}	9.375^{*}	210.04^{**}
N x P	3	0.9444^{ns}	2.2639^{**}	4.153^{*}	15.15^{ns}
Error	14	0.7143	0.3571	1.280	13.29

** = Significantly different at ($P \leq 0.01$); * = Significantly different at ($P \leq 0.05$);

ns = Not significantly different at ($P \leq 0.05$); d.f. = degrees of freedom

3b: Analysis of variance Table showing the mean squares of phenological parameters of maize measured during the 2001 cropping seasons

Source of variations	d.f.	Days to 50% tasselling	Days to 50% anthesis	Days to 50% silking	Days to 50% maturity
Replication	3	2.375	0.365	1.781	10.781
N	3	2.875^{ns}	2.031^{ns}	3.531^{ns}	7.365*
P	1	36.125**	47.531**	47.431**	132.031**
N x P	3	1.708^{ns}	1.365^{ns}	1.781^{ns}	2.865^{ns}
Error	21	1.042	1.103	1.353	2.424

** = Significantly different at ($P \leq 0.01$); * = Significantly different at ($P \leq 0.05$);
ns = Not significantly different at ($P \leq 0.05$); d.f. = degrees of freedom

Table 4a: Mean performance of phenological parameters of maize due to P treatments measured during the 2000 cropping season

P rates (kgha^{-1})	Days to 50% tasselling	Days to 50% anthesis	Days to 50% silking	Days to 50% maturity
0	63.33	65.08	65.58	83.42
60	61.50	63.33	65.33	77.50
LSD	0.690	0.523	0.991	3.192
F Prob.	0.001	< 0.001	0.017	< 0.001

LSD = Least Significant Difference

Table 4b: Mean performance of phenological parameters of maize due to P treatments measured during the 2001 cropping season

P rates (kgha^{-1})	Days to 50% tasselling	Days to 50% anthesis	Days to 50% silking	Days to 50% maturity
0	53.75	56.69	60.56	89. 50
60	51.63	51.25	58.13	85.44
LSD	1.061	0.772	0.855	1.145
F Prob.	< 0.001	< 0.001	< 0.001	< 0.001

LSD = Least Significant Difference

4.0 Conclusion

From the results of this study, it can be concluded that the basal application of 60kg P ha^{-1} achieved significant reduction in days to 50% tasselling, anthesis, silking and physiological maturity of maize in Yola and its environs, indicating that P application is critical for maize to show early phenological traits. It is also recommended that the experiment be conducted across different locations with varied ecology in Nigeria. Furthermore, similar experiment should be conducted with other varieties of maize in the same ecological zone to ascertain the effects of P on phenological traits of other varieties.

References

Allaby, M. (1988). *Macmillan Dictionary of Environment,* 3rd Edition. London. Pp. 358-359

Amanullah, R/A., Khattak, S., Khali, K.(2009b). Effects of plant density and N on phenology and yield of maize. *J. Plant Nutr*. 32 (3): 245-259). .

Bashir, A. (2000). Water quality and outbreak of diseases in Yola area of Adamawa State. An M.Sc. dissertation submitted to the Department of Geography, Federal University of Technology, Yola.

Black, C.A. (1965). Method of Soil Analysis. *Agronomy* No. 9 part 2. Am Soc. Agron. Madison Wisconsin

Bremmer, J.M. (1996). Total Nitrogen. In Black C.A. (ed). *Method of Soil Analysis*, part 2. ASA, Madison, Winscosin. Vol. 9.pp. 914-926

Chaundhary, A. R. (1983). Maize in Pakistan. Punjab Agricultural Research Coordination Board, University of Agriculture,

Downswell, C.R., Paltiwal, R.F. and Cantrell, R.L. (1996). *Maize in the third world*. West View Press. pp. 268

Duncan, W.G. (1975). Maize Crop physiology. Evans (ed). London: Cambridge University Press, pp. 23-50.

Frey, N. M. (1981). Dry matter accumulations in maize kernels of maize. *Crop Science* Vol. 1: pp 118-122

Hussein, M.Z. amd Haqq, I.U. (2000). Phosphorus absorption capacities of KPK soils. In: Proceedings of Symposium on integrated plant nutrient management held at Islamabad on 8-10 November. 1999. Pp. 284-296

Ibrahim, S. A. and Kandil, H. (2007). Growth yield and chemical constituents of Corn (*Zea mays*) affected by nitrogen and phosphorus fertilization under different irrigation Intervals. *Journal of Applied Sciences Research,* Vol. 3, pp 1112-11120

Ibrikei, H.J., Ryan, A.C., Ulger, G... Buyuk, B., Cakir, K., Korkmaz, E., Karnez, G., Ozgenturk, O. and Konuskan, C. (2005). Maintenance of P fertilizer and residual P effect on corn production. *Nigerian J. Soil Sci*. Vol 2.pp. 11271279-1286

Imran, I. (2015). Effect of germination on proximate composition of two maize cultivatars. *J. Bio and H. Care*. Vol.5 (3), pp 123- 128

Jones, C.A. (1985). *C_4 Grasses and Cereals. Growth, Development and stress response*. New York: Wiley, pp.16

Kochler, S.L. (1986). *Tropical crops. A text book of economic botany*. London: Macmillan pp. 88-98

Malarrino, A.P.; Bordolli, J.M and Borgues, R. (1999). Phosphorus and potassium placement effects on early growth and nutrient uptake of No-Till Corn and relationships with grain yield. *Agronomy Journal*, Vol.91, pp7-45

Miller, R. W. and Donahue, R. L. (1990). *An introduction to soil and plant growth*, 6th Edition. Prentice Hall. pp. 250

Nelson, D.M. and Sommers, L. (1996). Total carbon, organic carbon and organic matter. In: D.L. Spark (eds). *Methods of Soil Analysis part 3- chemical methods*. SSSA Book Series. Vol. 5, Madison Winscosin, USA, pp. 961-1010

Olsen, S.R.; Watanabe, F.S. and Dean, L.A. (1985). Estimation of available P in the soil by extraction with sodium bicarbonate. USDA: pp939

Page, A. L.; Miller, P.H. and Keeney, D.R. (1982). *Methods of Soil Analysis Part 2. Chemical and Microbiological properties*, 2nd Edition. USA: ASA. Inc. Madison Wisconsin

Reghurum, K., Singn, T.A., and Vasta, N.K. (2000). Effect of phosphate fertilization of different water solubility on maizeand residual on wheat in a mollisol. *Pantnagar J. of Res., Vol. 29*. pp. 40-43

RMRDC. (1997). *Raw Materials Sourcing for Manufacturing in Nigeria*. 3rd Edition, Abuja, pp146.