Influences of Organomineral and NPK 15-15-15 Fertilisers on the Yield of Maize and Weed Infestation

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Abstract:
Background: Use of organomineralfertiliser (OF) is becoming handy for ameliorating soil deficiencies for sustainable crop production. This has necessitated the establishment of commercially produced organomineralfertiliser to meet farmers need. However, reports have shown that fertilisers influence weed infestation thereby affecting the expected crop yield. Consequently, application rates of commercially produced OF on maize performance and their influence on weed infestation were evaluated.

Materials and Methods: Using 30 kg pots in completely randomised design with three replications, influences of OF (0, 50, 100, 150 kg/ha of N) and NPK 15-15-15 (400 kg/ha) were investigated in two cropping cycles. Treatments residual effects were also evaluated on maize dry matter yield.

Results: Maize dry shoot weight increased with increasing level of OF application. Dry shoot weight was highest at 150 kg/ha of N. The 100 kg/ha of N OF and NPK treatments gave significantly higher maize grain yields (57.06 and 54.35 g/pot) compared to the control (35.50 g/pot). However, maize grain yields under other treatments were not significantly different compared to the control. Total dry weed biomass ranged from 23.21 g/pot (control) to 30.58 g/pot (NPK 15-15-15) with no significant difference observed among treatments. Residual effects of OF application improved maize dry shoot weight with no significant difference observed among treatments.

Conclusion: Applying 100 kg/ha of N OF improved maize performance without appreciably increasing weed biomass.

Key words: Organomineral fertiliser, Dry shoot weight, Maize grain yield, Dry weed biomass, Residual effects

I. Introduction

Maize (Zea mays L.) is rank third in production, after wheat and rice throughout the world (Ranum et al., 2014). It is extensively cultivated in various countries of the world (tropical, subtropical and temperate areas). In Nigeria, maize is grown in nearly every agro-ecological region of the country (Adiaha, 2018), and according to FAOSTAT (2018), an average of 8.7 million tonnes is produced annually. maize production inNigeriawas 10.06 million tonnes in 2014, 10.56 million tonnes in 2015and 10.41 million tonnes in 2016 (FAOSTAT, 2018). Hence, there has been inconsistency in maize yield over the years despite the consistent increase in land area for production.

These inconsistencies in yield were as a result of minimal adoption of complementary inputs such as fertiliser (and other practices relating to soil fertility improvement) and improve weed management practices (Týr, 2015; Reetz, 2016; Zerihun, 2017). The average local farmers maize yield in Nigeria ranges from 1.12-2.2 t ha⁻¹ (Ammani, 2015). This, according to the FAO statistics was below the expected maize yield range of 1.5-6.0 t ha⁻¹ based on recommended agronomic practices in Nigeria (FAOSTAT, 2018).

Maize is high nutrient demanding with the resulting nutrient-extraction ability limiting yields and thereby inadequate production in many areas (Ten Berge et al., 2019). Umeh and Mbah (2010) reported that the degree of soil nutrient mining due to intensification of agricultural production results in serious land degradation and large shortages for nitrogen, potassium and magnesium. Sustainability of agriculture is threatened when adequate restoration of soil fertility is not matched with agricultural intensification (FAO, 2003). Therefore, a sustainable approach to preserving soil fertility and continuous crop production is essential. Applications of soil amendments such as manures, chemical fertiliser, biochar and mycorrhizal inoculation to improve the productivity of tropical soil have been reported (Fagbola and Dare, 2003; Faloye et al., 2017).

Fertilisers are major factor when considering crop production increment (Zerihun, 2017). Report has shown that improvements in soil fertility increase agricultural productivity, increased food security, and rural income (Adiaha, 2018). However, improved cultural and land management practices are equally necessary to improve crop yield. In every region of the world, sharp increase in the use of fertiliser is associated with crop-based agriculture intensification (Morris et al., 2007).

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Crop productivity sustenance using chemical fertiliser has not been effective on a long-term basis. It often leads to soil acidification, decline in soil organic matter and soil physical degradation (Geiseller and Scow, 2014). Also, the traditional farmers are financially poor to buy the scarce and costly inorganic fertiliser (Morris et al., 2005; Liverpool-Tasie et al., 2017). The benefits derivable from the use of organic materials are yet to be fully annexed in the humid tropics. This has been attributed to the high cost of handling and transportation and the large quantities of fertiliser required to satisfy the nutritional needs of crops (Morris et al., 2005). Organomineral fertiliser was formulated as an alternative to mitigate the problems associated with conventional inorganic fertiliser and thereby increasing the frequency of land use to approach continuous crop production. The common problems associated with both chemical fertiliser and manure when used separately could be removed by integrating the materials to achieve better effects (Omueti et al., 2000; Gang et al., 2019). Integrated fertiliser management approaches are low cost because only small quantity of chemical fertiliser is required with animal manure (Reetz, 2016). The organomineral fertilisers used by many researchers were individually compounded, thereby making them unavailable to the farmers at required quantity. Reports have also shown inconsistency in organomineral fertiliser recommendations to farmers (Makinde, 2007; Agba et al., 2012; Chukwuka et al., 2014; Kekere and Omoniyi, 2016). In order to overcome this problem, some commercial manufacturers in Nigeria have embarked on the production of organomineral fertiliser. However, there is the need to ascertain the level of application of these commercial organomineral fertilisers for optimum yield.

Furthermore, farmers and researchers have recognized the effect of fertiliser application on weed management in croplands (Sweeney et al., 2008; Efthimiadou et al., 2012). The interaction between fertilisers and weeds can be positively or negatively correlated with weed infestation (Liebman et al., 2004; Sweeney et al., 2008; Tyr, 2015). According to Bajwa et al. (2014), fertiliser use can influence weed emergence, weed persistence, weed growth and weed dispersion attributes. Weeds compete with cultivated crops for nutrients applied through fertiliser application; hence, contributing to the reduction of expected crop quality and yield (Efthimiadou et al., 2012; Mick, 2016; Shah et al., 2016). Therefore, the objective of this study was to determine the best rate of Pacesetter (commercial) organomineral fertiliser on weed incidence and the performance of maize.

II. Material and Methods

This study was conducted on research farm of the University of Ibadan (latitude 7°17′29.83′′N and longitude 4°16′31.88′′E) in Ayeye (Isokan LGA), Osun State, Nigeria. Composite samples of the top soil (0-20 cm) were collected with auger from the experimental sites before starting each experiment. The soil samples were air-dried and passed through a 2 mm mesh sieve for physical and chemical analysis. The soil samples and pacesetter fertilisers were analysed in the Department of Agronomy service laboratory as described in the IITA laboratory manual (IITA, 1982) for particle size distribution and nutrients content.

The ideal organomineral fertiliser rate for maize was evaluated in 30 kg/pot of sieved top-soil. The treatments were control, organomineral fertiliser (50, 100 and 150 kg/ha of N) and NPK 15-15-15 (at 400 kg ha⁻¹ as recommended by IITA (2007). The experiment was in completely randomized design with three replications in two cropping cycle.

Maize (Suwan-1 variety) was sown at 3 seeds/pot. The maize was later thinned to 2 plants/pot at 2 weeks after planting (WAP). Weeding operation was carried out when necessary. The treatments described above were applied to the designated plastic pots containing 30 kg of sieved top-soil that was low in phosphorus.

Residual experiment to assess the effects of fertiliser applications was carried out after the initial maize cropping.

The observations of weed dry matter were taken from each treatment at 4, 8 and 12 WAP. Maize plant samples were collected from each pot and dried in an oven at 70 °C to a constant weight to determine the shoot dry matter weight. Yield component such as number of seeds/cob, shelling percentage, cob weight/pot, and grain yield/pot (at 14 % moisture content) were determined. Data on residual maize cropping was on maize dry shoot weight at 12 WAP.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System, and the means separated using Least significant difference (LSD) at P < 0.05 level of significance, where F-ratio was significant.

III. Results and Discussion

The characteristics of the soil showed that pH (H₂O) was 6.3 unit, while the organic carbon was 11.5 g/kg. The soil was found to be slightly acidic. The total N was 0.78 g/kg, while available P was 5.83 mg/kg. The respective values for K, Na, Mg, and Ca in the soil were 195, 234, 936 and 2028 mg/kg. The Exchangeable...
Influences of Organomineral and NPK 15-15-15 Fertiliser on the Yield of Maize and Weed Infestation

Cation Exchange Capacity was 9.1 cmol/kg and the exchangeable acidity was 0.5 cmol/kg. The sand fraction was dominant in the soil and had 844.0 g/kg. The silt fraction was 80.0 and the clay fraction 76.0 g/kg. The soil textural class (loamy sand) contains clay and silt in adequate proportion to hold enough water for good plant growth and to guard against short duration drought (Kekere and Omoniyi, 2016). Nitrogen, P and K showed the fertility status of the soils to be low when compared to maize critical levels recommended by Adeoye and Agboola (1985) for optimum production. The fertility status of the soil would not support optimum maize growth.

The organic matter content of the organomineral fertiliser (OF) was just adequate (Table 1). The N content in the material was higher than the normal N found in sole manures but still not adequate for organomineral fertiliser. However, the available P and exchangeable K were low. The C:N ratio of the organomineral fertiliser was 20.9.

<table>
<thead>
<tr>
<th>Properties (%)</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>1.88</td>
</tr>
<tr>
<td>Organic C</td>
<td>39.3</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.23</td>
</tr>
<tr>
<td>Potassium</td>
<td>1.01</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.64</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.23</td>
</tr>
</tbody>
</table>

The maize dry shoot weight increased with the increasing in OF application, including NPK (Table 2). The dry shoot weight showed significant effect of NPK and 150 kg/ha of N organomineral fertiliser application compared to the control. Other treatments were not significantly different from the control. The increase in yield component might be due to increase in available nitrogen, which resulted in the increase dry shoot weight. The observation agreed with Arjjeet al. (2018) findings, who reported that higher application of fertiliser caused increased maize dry matter yield.

The cob yield had significantly higher values at 100 kg/ha of N OF and NPK compared to the control. The application of 50 and 150 kg/ha of N OF treatments gave 11.46% and 37.68% respectively higher yield than the control but were not significant. Similar result was reported by Raja (2001) that 120 kg ha⁻¹ N resulted in significantly higher cob yields than the control.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Dry shoot weight (g/pot)</th>
<th>Cob yield (g/pot)</th>
<th>Number of seeds/pot</th>
<th>Shelling %</th>
<th>Grain yield (g/pot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kg N</td>
<td>211.88</td>
<td>44.14</td>
<td>129.79</td>
<td>54.23</td>
<td>35.50</td>
</tr>
<tr>
<td>50 kg/ha of N OF</td>
<td>216.04</td>
<td>47.45</td>
<td>161.46</td>
<td>75.92</td>
<td>37.28</td>
</tr>
<tr>
<td>100 kg/ha of N OF</td>
<td>216.67</td>
<td>73.90</td>
<td>225.79</td>
<td>72.50</td>
<td>57.06</td>
</tr>
<tr>
<td>150 kg/ha of N OF</td>
<td>266.25</td>
<td>60.77</td>
<td>240.67</td>
<td>70.23</td>
<td>46.25</td>
</tr>
<tr>
<td>NPK 15-15-15</td>
<td>261.88</td>
<td>71.07</td>
<td>236.79</td>
<td>65.26</td>
<td>54.35</td>
</tr>
<tr>
<td>LSD</td>
<td>47.32</td>
<td>26.92</td>
<td>97.92</td>
<td>11.52</td>
<td>18.06</td>
</tr>
</tbody>
</table>

OF, Organomineral fertiliser

In some related studies, Arijje et al. (2018) reported an increase in cob and ear weight of maize treated with organomineral fertiliser. The number of seeds/plant ranged from 129.79 to 240.67 in the control and 150 kg/ha of N, respectively. The number of seed/pot increased with increasing organomineral fertiliser application, with significances observed at 150 kg/ha of N and NPK compared to the control. However, there were no significant differences between the effects of 100 and 150 kg/ha of N levels on the number of seeds/plant, this was consistent with the report of Ngosong et al. (2019). Similarly, Agba et al. (2012) reported that the interaction between poultry manure at 10 t ha⁻¹ and 600 kg ha⁻¹ NPK fertiliser gave the highest number of grains/cob. The order of increase in maize number of seeds/pot are 150 kg/ha of N OF>NPK>100 kg/ha of N OF>50 kg/ha of N OF>0 kg N.

The highest shelling percentage was observed at 50 kg/ha of N, whiles the lowest was observed in the control. The values were significantly different. Similarly, 100 and 150 kg/ha of N gave significantly higher shelling percentages than the control. The application of NPK did not significantly improved shelling percentage of maize compared to the control. This is in line with the observation of Makinde (2007) report that organomineral fertiliser application increased maize shelling percentage than the control. Similarly, the application of fertiliser improved shelling percentage in maize (Yusuf et al., 2019).

The grain yield result of a crop is the output effect of all the complex morphological and physical processes that occur throughout the growth and development of a crop. Hence, the importance of yield results in crop experiments. The application of organomineral fertiliser is expected to enhance soil productivity, increase soil organic matter content, soil flora and fauna, improve soil crumb structure and the nutrient status of the soil.
consequently attaining sustainably high yields (Morris et al., 2007). The increase in organomineral fertiliser application significantly increased maize grain yield at 100 kg/ha of N. However, there was slight grain reduction at 150 kg/ha of N compared to the 100 kg/ha of N. According to the Liebig law of minimum, yield is increased to maximum with addition of any nutrients to a level, then it tends to be decreased to minimum with removal of that nutrient (Shiyam et al., 2014). The application of 100 kg/ha of N and NPK significantly increased maize grain yields compared to the control. Inorganic fertilisers have been reported to release their nutrients rather fast for the plants to utilize (Reetz, 2016). This accounts for the observed high value of maize grain yield in the inorganic fertiliser treatment than organomineral fertiliser (except 100 kg/ha of N) or the control. Application of the other organomineral fertiliser levels did not significantly improved grain yield in maize compared to the control. Ahmed et al. (2007) also support this finding in maize on sorgum. This may have resulted from the availability of nitrogen required for improved plantgrowth and development, which translated to increased grain yield. Agba et al. (2012) reported that 5 and 10t ha\(^{-1}\) poultry manure improved maize yield by 42% and 101% respectively, over the control. Each increment in NPK rates significantly increased grain yield up to the 400 kg ha\(^{-1}\) rate but yield was reduced by 14% at the 600kg ha\(^{-1}\) NPK rate. Report by Dada and Ewulo (2015) showed that 5 poultry manure and 100 urea+30 SSP enhanced maize production. Arriet et al. (2018) also reported higher application of fertiliser caused increased grain yield in maize. The order of the influence by treatments on maize grain yield are NPK>100 kg/ha of N>N>50 kg/ha of N>0 kg N. However, Arriet et al. (2018) reported that increasing nitrogen fertiliser application at higher rate increased yield and yield components in maize.

Dry weed biomass was significantly higher in pots treated with NPK 15-15-15 compared with the control at 4 and 8 WAP (Table 3). This was in support of Sweeney et al. (2008) report that N application influenced the germination, emergence and competitiveness of different weeds positively. However, application of Pacesetter organomineral fertiliser was not significantly different from the control at 4 WAP. At 12 WAP, significantly higher weed biomass was observed in the control compared to the other treatments. With respect to cumulative weed biomass, no significant difference was observed among the treatments. However, application of NPK 15-15-15 fertiliser produced the highest weed biomass, while the lowest was observed in the control. This was in line with Mick (2016) and Shah et al. (2016) that fertiliser application improves crop performance and increased weed occurrence. According to Adigun et al. (2018) report on tomato, increase of cumulative weed biomass observed could be attributed to higher N level increased crop competitiveness for available resources hence, it enhanced better dry matter accumulation at the detriment of competing weed species. The higher increase in weed biomass from NPK treated pots over organomineral fertiliser were attributed to the fact that inorganic fertiliser remains on the surface of the soil thereby providing more nutrient to the weeds which resulted in their increase in biomass (Corrêa et al., 2016; Knight, 2017). Similarly, increasing the rate of application enhanced weed biomass as was reported by Baker et al. (2018). However, the increased of Pacesetter organomineral fertiliser application improved cumulative weed biomass with no significant influence in suppressing maize yield. The relative reduction in cumulative weed biomass observed in the OF treated pot compared to the NPK fertiliser may be attributed to the possibility of the microorganisms in the OF in tying up the nitrogen in the residue thereby making it readily unavailable for weed uptake (Sweeney et al., 2008). The reduction in weed biomass with subsequent readings over the period of observation may be attributed to the reduction in seed bank of weeds through weeding operations (Buhler, 1999; Prithviraj et al. 2018; Maqsood et al., 2018).

<table>
<thead>
<tr>
<th>Weeks after planting</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>cumulative weed biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kg N</td>
<td>10.83b</td>
<td>0b</td>
<td>3.33a</td>
<td>14.16a</td>
</tr>
<tr>
<td>50 kg/ha of N OF</td>
<td>14.84ab</td>
<td>2.26a</td>
<td>0.56b</td>
<td>17.66a</td>
</tr>
<tr>
<td>100 kg/ha of N OF</td>
<td>14.73ab</td>
<td>0.78ab</td>
<td>0.48b</td>
<td>15.99a</td>
</tr>
<tr>
<td>150 kg/ha of N OF</td>
<td>14.78ab</td>
<td>1.72ab</td>
<td>0.41b</td>
<td>16.91a</td>
</tr>
<tr>
<td>NPK 15-15-15</td>
<td>19.78a</td>
<td>1.9a</td>
<td>0.71b</td>
<td>22.39a</td>
</tr>
<tr>
<td>LSD</td>
<td>7.91</td>
<td>1.87</td>
<td>2.08</td>
<td>ns</td>
</tr>
</tbody>
</table>

OF: Organomineral fertiliser

Residual effect of organomineral fertiliser application improved maize dry weight with increase in the level of application (Table 4). Similarly, residual effect of NPK fertiliser improved maize dry weight compared to the control. The residual effects of organomineral fertiliser or NPK fertiliser did not result in significantly greater maize dry weight than the control. However, the order of maize dry weight increase was 150 kg/ha of N>100 kg/ha of N>50 kg/ha of N>NPK>control. The increase in maize dry weight resulting from residual effect of organomineral fertiliser over the NPK or the control is in line with the works of Oshunsanya and Akinrinola (2013) and Loks et al. (2014). Similarly, effect of cow manure on poultry manure combined with urea fertiliser was reported to increase hybrid maize than the single application of poultry manure or urea (Khaliq et
Influences of Organomineral and NPK 15-15-15 Fertiliser on the Yield of Maize and Weed Infestation

al., 2008). This was attributed to the increase in organic matter in the organomineral fertiliser which seems have contributed enough N to the soil which created the difference. Arije et al. (2018) also reported that the residual effect of NPK was not as prominent as those of farm yard manure or poultry manure combined with NPK were not significant.

Table 4: Effects of residual application fertiliser on dry shoot weight (g/pot) in maize

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Maize Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kg N</td>
<td>17.37</td>
</tr>
<tr>
<td>50 kg/ha of N OF</td>
<td>19.02</td>
</tr>
<tr>
<td>100 kg/ha of N OF</td>
<td>20.68</td>
</tr>
<tr>
<td>150 kg/ha of N OF</td>
<td>21.70</td>
</tr>
<tr>
<td>NPK 15-15-15</td>
<td>18.58</td>
</tr>
<tr>
<td>LSD</td>
<td>ns</td>
</tr>
</tbody>
</table>

OF, Organomineral fertiliser

This was reported to be a characteristic nature of organomineral fertiliser (Roy et al., 2006). The applied N was, therefore, not made totally available to the crops and so, plants under organomineral fertiliser had higher values than observed from the inorganic or control.

IV. Conclusion

The observed significant performance in growth and yield parameters with the application of 100 kg/ha of Norganomineralfertiliser could be regarded as being the adequate level for best maize grain yield in the location of the study. The increase in the level of organomineral fertiliser (150 kg/ha of N) application resulted in the increase in maize dry shoot weight and decreased in maize grain yield. Application of Pacesetter organomineral fertiliser did not increase weed incidence to a detrimental level for maize production.

References


DOI: 10.9790/2380-1306014146 www.iosrjournals.org 45 | Page


DOI: 10.9790/2380-1306014146 www.iosrjournals.org 46 | Page