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INFLUENCE OF WEED CONTROL METHODS, POULTRY MANURE AND PLANTING PATTERN ON GROWTH AND YIELD ATTRIBUTES OF MAIZE (*Zea mays* L.) IN THE NORTHERN GUINEA SAVANNAH ZONE OF NIGERIA

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ABSTRACT

*Field trials were conducted during the rainy seasons (2012 and 2013) at the Research Farm of Institute for Agricultural Research, Samaru Zaria and College of Agriculture and Animal Science, Mando Kaduna, in the Northern Guinea Savannah Zone of Nigeria, to determine the Influence of weed control methods, poultry manure and planting pattern on the performance of maize (*Zea mays* L.). The treatments consisted of six levels of weed control (S-metolachlor + atrazine at 1.98 and 2.64 kg a.i./ha, butachlor at 1.5 and 2.5 kg a.i./ha, hoe weeding at 3 and 6 weeks after sowing (WAS) and a weedy check), three levels of poultry manure (0, 4 and 8 t/ha) and two planting pattern (single and double row per ridge). The treatments were laid out in spit-plot design replicated three times. Weed control and poultry manure were assigned to the main plots, while planting pattern was assigned in the sub-plots. Results from the study showed that application of S-metolachlor + atrazine at 2.64 kg a.i./ha, butachlor at 2.5 kg a.i./ha and hoe weeding at 3 and 6 WAS produced taller maize plants, increase in relative growth rate and higher grain yield. However, application of poultry manure at 8t/ha gave the tallest maize plants, increase in relative growth rate and higher total grain yield, while double planting pattern (double row per ridge) suppressed weed population and ensured better crop performance and higher grain yield compared to the single planting pattern (single row per ridge).*

Key words: weed control, planting pattern, poultry manure

INTRODUCTION

Maize (*Zea mays* L.) is the world's third most important crop after rice and wheat. It is grown in developing countries and is the most commonly grown cereal in Nigeria, with an annual production of 11.3 million metric tons. It is widely cultivated throughout the world and a greater quantity is produced each year than any other grain (FAO, 2014). According to Food and Agriculture Organization (FAO, 2014), maize yields currently average 1.5 t/ha in Africa, slightly more than 3 t/ha in Latin America, and 1.7 t/ha in India. Brazil currently stands out as one of the largest maize producers in the world, with an estimated production of 79,000 tons in the 2013/2014 harvest. A total of 826.2 million metric tons of maize were produced worldwide (FAO, 2014).

Maize is used as a major food crop, livestock feed and as a raw materials for industrial products e.g in Australia as feed, silage breakfast food and processing (breakfast cereals, corn, chips, grits and flour), industrial starch and popcorn. In Sub-Saharan Africa, maize is a staple food for estimated 50% of the population and provides 50% of the basic calories. It is an important source of carbohydrate, protein, iron, vitamin B, and minerals, past grits and beer. Green maize (fresh on the cob is eaten parched, baked, roasted or boiled and plays an important role in filling the hunger gap after the dry season (Stinger *et al.*, 2015b). Thus maize more than any crop, offers the

promise of meeting Africa's food need in this millennium (Idem and Showemimo, 2014).

Maize production in Nigeria is seriously constrained by weed infestation. Weeds affect maize by competing for nutrients, light, water and space. Weeds harbor insect pests that damage the crop (Ogundele, 2006). The estimated losses due to uncontrolled weeds are about 80% of the potential grain yield of maize (Lagoke *et al.*, 1986). Also, Anikwe *et al.* (2000) reported that total crop failure may occur in maize crop if weeds are not controlled. These workers also observed that keeping maize crop weed free for 60 days after sowing increased grain yield by 60% compared to the weedy check. Weed interference not only results in crop losses, but also generally conceded that the current economic damage to agriculture from weeds far surpasses the more incidental damage inflicted by insect pest, rodents and diseases (Oudejans, 1991). On the other hand, use of chemical fertilizer has not provided adequate measures in maintenance of soil fertility for sustaining the productivity (Sharma and Mitra, 1991, Yahaya, 1993). Nitrogen increases maize production in the Guinea Savannah Ecological Zone of Nigeria (Singh *et al.*, 2001, EL-Gizawy and Saleem 2010 and Sharifai, 2011). The use of chemical fertilizers to supplement nitrogen source is appreciated by farmers but high cost of fertilizer, poor distribution, adulteration, low subsidy, scarce financial resource and in adequate credit facilities made the commodity not easily accessible.

There is, therefore, the need to seek for alternative to inorganic fertilizer. Poultry manure may serve as a renewable source of nitrogen. Hence it can be a good alternative to reduce these problems. There is also serious health problem in the use of chemical fertilizer, diminishing food quality due to chemical deposit in crop fruits and seeds. Sharma (2001) also stated that the use of poultry manure is capable of solving the mentioned limitations because of its ability to improve physical, chemical and biological properties of soil. Furthermore, maize is cultivated in rows, however, recently there has been an interest of different planting pattern, such as double and single pattern row per ridge. Several reports revealed that double planting pattern produced higher grain yield than the single planting pattern (Sener, *et al.*, 2004 and Sarlangue, *et al.*, 2007). Maize is widely grown in savanna ecological zone, but farmers do not adhere to planting pattern. Saberali (2007) reported that double planting pattern (double row per ridge) increased leaf area index, total dry matter and crop growth rate compare to single planting. Single planting pattern (single row per ridge) increased the incidence of weed competition (Munamara, *et al.*, 2006; Gozubenli, 2010). It is, therefore recommended for farmers to adhere to double planting pattern, than the conventional pattern which may suppress weeds, thereby reducing competition and increasing maize yield. Cox *et al.* (2006) stated that double planting pattern had greater corn silage dry matter than the single planting pattern. Hashemi, *et al.* (2005) reported that double planting pattern produced more yield than the single planting pattern.

The study was therefore conceived with the objective of determining the influence of weed control methods, poultry manure rates and planting pattern on weed infestation on the performance of maize (*Zea mays* L.) in the Northern Guinea Savanna Zone of Nigeria.

MATERIALS AND METHODS

Field trials were conducted during the rainy seasons of 2012 and 2013 at the Research Farm of the Institute for Agricultural Research, Samaru (11⁰11¹N, 0.7⁰ 38⁰E and 686 meters above sea level) and College of Agriculture and Animal Science, Mando Kaduna, (7.43⁰N 8.33⁰E of the equator and 632 meters above sea level) in the Northern guinea savanna zone of Nigeria. The treatments consisted of six levels of weed control (S-metolachlor + atrazine at 1.89 and 2.64 kg a.i/ha, butachlor at 1.5 and 2.5 kg a.i/ha, two hoe weeding at 3 and 6 weeks after sowing (WAS) and a weedy check). Three levels of poultry manure (0, 4 and 8 t/ha) and two planting pattern (single and double row per ridge). The treatments were laid out in a split plot design and replicated three times. The weed control treatments and poultry manure were assigned to the main plots while planting pattern was assigned to the sub-plots. The gross and net plot area sizes were 18m² and 12m² respectively. Composite soil samples were also collected for their physic and chemical properties in each year, with an auger of 10 cm diameter at the depth of 0 -30cm in which the samples were air dried and sieved using standard procedure as described by (Black, 1968). Poultry manure used during the trials at

both Samaru and Mando in the 2012 and 2013, were sourced from layers dropping. Dried samples of the poultry manure were grinded and analysed for N, P and K. The total nitrogen was determined by Micro-kjeldahl method (Bremmer, 1965). Available phosphorous was analyzed according to Bray's method described by Olsen *et al.*, (1986). Poultry manure was applied manually by spreading and incorporation into the soil on treatment basis, two weeks prior to sowing. Data on rainfall distribution, temperature, sunshine and relative humidity for the 2012 and 2013 raining seasons were collected at Samaru Meteorological Unit of Institute for Agricultural Research Station and at Meteorological Unit of National Airport Research Station (Nimet, Kaduna). The experimental sites were ploughed, harrowed to a fine tilth at both locations, in both years and ridged 75cm apart with a tractor. The sites were marked out into 108 plots with three (3) replications. An alley way of one meter across and one ridge along the plots were used as borders between the plots, while replications were separated by two ridges. The gross plot and net plot sizes was 18m² and 12m² respectively. The maize variety used in the trial was SAMMAZ 37. It is a medium maturing variety and can attain a height of about 170cm and tolerant to *Striga hermonthica*. It is resistant to maize streak virus and also drought tolerant. The seeds are yellow in color and have a yield potential of about 4.5 t/ha. The seeds were sown manually at the rate of two seed per hole along the ridges, using an intra row spacing of 25cm and later were thinned to one plant per stand at 2 weeks after sowing. The herbicides were applied on treatment basis using a CP3 knapsack sprayer fitted with a green deflector polyjet nozzle and set at a pressure of 2.1kg/m² that gave a spray volume of 250 l/ha. Hoe weeding was carried out at 3 and 6 weeks after sowing (WAS) for the hoe weeding treatment at both sites and years of the experiment. The crop was harvested as the plants attained physiological maturity. The ears from the net plots were removed manually and de-husked. The cobs were sun dried and later shelled and winnowed in the air to obtain clean grains. Data collected was subjected to statistical analysis of variance (ANOVA) using general linear model GLM of the Statistical Analysis System package (SAS, 2003). The treatment means were separated using Duncan's multiple range test (Duncan, 1955).

RESULTS

Influence of weed control, poultry manure and planting pattern on plant height of maize at 9 weeks after sowing

The influence of weed control, poultry manure and planting pattern on plant height of maize at 9 WAS is presented in (Table 1). Results showed that control of weeds with hoe weeding at 3 and 6 WAS, gave significantly taller plants, than all the herbicides and the weed check at both locations in all the years and their mean. Among the herbicides that were evaluated, application of higher rate of S-metolachlor + atrazine at 2.64kg a.i/ha at Samaru and Mando in 2012 and butachlor at 2.5kg a.i/ha at Mando in 2012 recorded tallest maize plants, than all the other rates of herbicides at both locations and in both years (Table 1).

Significantly taller maize plants was obtained with 8 t/ha of poultry manure was obtained at both locations, and in both years, which was similar with 4 t/ha of poultry manure at Samaru in 2013 and at Mando also in 2013, than with application of 4t/ha of poultry manure at both locations in 2012 and mean. While shortest maize plants were recorded with non application of poultry manure throughout the locations, years and the means (Table 1).

The results further revealed that planting pattern with both the single and double pattern was not significant at both locations, in all years and their means, but higher mean values were recorded in the double planting pattern at Samaru in 2012 and mean.

Influence of weed control, poultry manure and planting pattern on relative growth rate of maize at 9 weeks after sowing

Table 2 showed that weed control treatments, poultry manure and planting pattern during the sampling period of 9 WAS on relative growth rate of maize was significant throughout the locations, years and the means. Influence of weed control treatments significantly recorded the highest increase on relative growth rate of maize with hoe weeding at 3 and 6 WAS throughout the locations, years and the means, which was statistically similar with application of higher rate (2.5kg a.i/ha) of butachlor at both Samaru and Mando in 2012, than all other herbicides and the weedy check (Table 2).

Influence of poultry manure application gave higher increase in relative growth rate with application of 8 t/ha of poultry manure, than with application of 4 t/ha, while lower relative growth rate was obtained

with the control, at both locations, years and their means.

Planting pattern at both locations in all years and means was however not significant, with both the single and double planting pattern on the relative growth rate, but higher mean values was obtained at Samaru in 2012 and at Mando in both years and mean (Table 2).

Influence of weed control, poultry manure and planting pattern on total grain yield of maize

Weed control, poultry manure and planting pattern had significantly influence total grain yield of maize in all the locations and years as presented in (Table 3). Weed control treatments with hoe weeding at 3 and 6 WAS, recorded the highest grain yield of maize in both locations, years and the means, which was similar with application of S-metolachlor + atrazine at 2.64 kg a.i/ha at Samaru in 2012 and at Mando in both years, butachlor at 2.5kg a.i/ha at Samaru in 2012 and also with butachlor at 1.5 and 2.5 kg a.i/ha at Mando in 2012, than with other herbicides and the weedy check (Table 3).

Poultry manure application, in all the locations, years and means gave highest grain yield with 8 t/ha of poultry manure application, being higher than with application of 4 t/ha of poultry manure, but less grain weight was obtained with non application of poultry manure, at both locations, years and the means.

Influence of planting pattern on grain yield recorded significantly highest grain yield of maize with double planting pattern compared to the single planting pattern across the locations, years and the mean (Table 3)

Table 1: Influence of weed control methods, poultry manure and planting pattern on plant height (cm) of maize (*Zea mays* L.) at 9 WAS at Samaru and Mando during 2012 and 2013 rainy seasons

| Treatment | Rate In kg a.i/ha | 2012 | Samaru 2013 | Mean | 2012 | Mando 2013 | Mean |
|---------------------------------|----------------------|---------|----------------|---------|----------|---------------|----------|
| Weed Control | | | | | | | |
| S- met + atra | 1.98 | 91.52c | 97.93bc | 94.73c | 103.50c | 102.94b | 103.22c |
| S- met + atra | 2.64 | 98.03ab | 100.21b | 99.12b | 110.84ab | 103.75b | 107.30b |
| Butachlor | 1.5 | 93.84bc | 94.92bc | 94.16c | 108.96bc | 104.32b | 106.64bc |
| Butachlor | 2.5 | 97.14b | 97.92bc | 97.53bc | 112.11ab | 105.66b | 108.88b |
| Hoe Weeding | 3 & 6 WAS | 102.98a | 105.86a | 104.42a | 116.26a | 110.96a | 113.61a |
| Weedy Check | | 63.14d | 72.58d | 67.86d | 76.72d | 73.94c | 75.33d |
| S.E± | | 4.900 | 4.362 | 3.512 | 6.110 | 0.052 | 3.522 |
| Poultry Manure (tons/ha) | | | | | | | |
| 0 | | 64.79c | 70.71c | 67.75c | 72.21c | 74.89c | 73.55c |
| 4 | | 87.89b | 110.84ab | 89.21b | 102.88b | 112.23ab | 98.56b |
| 8 | | 120.99a | 122.95a | 121.95a | 139.11a | 131.66a | 135.39a |
| S.E± | | 3.492 | 3.093 | 2.482 | 4.320 | 2.162 | 2.490 |
| Planting Pattern | | | | | | | |
| Single | | 90.08 | 94.82 | 92.46 | 104.61 | 100.19 | 102.40 |
| Double | | 92.14 | 94.84 | 93.49 | 104.86 | 100.34 | 102.60 |
| S.E± | | 2.121 | 0.372 | 1.082 | 0.990 | 0.532 | 0.560 |
| Interaction | | | | | | | |
| W * PM | | NS | NS | NS | NS | NS | NS |
| W * PP | | NS | NS | NS | NS | NS | NS |
| P M* PP | | NS | NS | NS | NS | NS | NS |
| W*PM*PP | | NS | NS | NS | NS | NS | NS |

Means within a column of any set of treatment group with unlike letter(s) are significantly different at P ≤ 0.05 using DMRT

Table 2: Influence of weed control methods, poultry manure and planting pattern on relative growth rate of maize (*Zea mays* L.) (g g⁻¹ wk⁻¹) at 9 WAS, at Samaru and Mando during 2012 and 2013 rainy seasons

| Treatment | Rate In kg a.i./ha | Samaru | | | Mando | | |
|---------------------------------|--------------------------|---------|---------|---------|---------|--------|---------|
| | | 2012 | 2013 | Mean | 2012 | 2013 | Mean |
| Weed Control | | | | | | | |
| S – met + atra | 1.98 | 0.261b | 0.311c | 0.286c | 0.325c | 0.350b | 0.338c |
| S – met + atra | 2.64 | 0.263b | 0.320bc | 0.291bc | 0.334bc | 0.359b | 0.347bc |
| Butachlor | 1.5 | 0.265b | 0.311c | 0.288c | 0.350bc | 0.353b | 0.352bc |
| Butachlor | 2.5 | 0.282ab | 0.328b | 0.308b | 0.354ab | 0.363b | 0.359b |
| Hoe Weeding | 3 & 6 WAS | 0.296a | 0.346a | 0.321a | 0.377a | 0.401a | 0.390a |
| Weedy Check | | 0.178c | 0.226d | 0.202d | 0.219d | 0.230c | 0.225d |
| S.E± | | 0.001 | 0.011 | 0.004 | 0.041 | 0.001 | 0.002 |
| Poultry Manure (tons/ha) | | | | | | | |
| 0 | | 0.20c | 0.246c | 0.223c | 0.288c | 0.309c | 0.299c |
| 4 | | 0.27b | 0.315b | 0.292b | 0.326b | 0.339b | 0.333b |
| 8 | | 0.30a | 0.360a | 0.331a | 0.366a | 0.380a | 0.373a |
| S.E± | | 0.001 | 0.009 | 0.006 | 0.005 | 0.009 | 0.001 |
| Planting Pattern | | | | | | | |
| Single | | 0.256 | 0.307 | 0.281 | 0.327 | 0.343 | 0.335 |
| Double | | 0.259 | 0.307 | 0.283 | 0.326 | 0.343 | 0.335 |
| S.E± | | 0.003 | 0.006 | 0.001 | 0.009 | 0.006 | 0.004 |
| Interaction | | | | | | | |
| W * PM | | NS | NS | NS | NS | NS | NS |
| W * PP | | NS | NS | NS | NS | NS | NS |
| P M* PP | | NS | NS | NS | NS | NS | NS |
| W*PM*PP | | NS | NS | NS | NS | NS | NS |

Means within a column of any set of treatment group with unlike letter(s) are significantly different at $P \leq 0.05$ using DMRT

Table 3: Influence of Weed Control methods, Poultry Manure and Planting Pattern on the Performance of maize (*Zea mays* L.) on total grain yield of maize (kg) at Samaru and Mando during 2012 and 2013 rainy seasons

| Treatment | Rates kg a.i./ha | Samaru | | | Mando | | |
|---------------------------------|---------------------|-----------|----------|-----------|----------|-----------|----------|
| | | 2012 | 2013 | Mean | 2012 | 2013 | Mean |
| Weed Control | | | | | | | |
| S-met + atra | 1.98 | 1856.66bc | 1800.31b | 1828.49bc | 2373.8b | 2153.18d | 2263.51b |
| S-met + atra | 2.64 | 3291.98ab | 2903.36b | 1910.67b | 3499.1ab | 3382.39ab | 2365.77b |
| Butachlor | 1.5 | 1734.39c | 1856.06b | 1795.22c | 3487.1ab | 3173.69cd | 2330.40b |
| Butachlor | 2.5 | 3284.42ab | 1902.65b | 1922.53b | 3505.5ab | 3215.55bc | 2360.50b |
| Hoe Weeding | 3 & 6 WAS | 3303.62a | 2177.51a | 2240.56a | 3704.8a | 3953.89a | 2629.34a |
| Weedy Check | | 760.89d | 928.01c | 844.30d | 2373.8b | 2246.51e | 1015.83c |
| S.E± | | 174.890 | 104.913 | 104.157 | 253.155 | 104.093 | 128.146 |
| Poultry Manure (tons/ha) | | | | | | | |
| 0 | | 900.61c | 872.07c | 886.34c | 1170.9c | 1017.70c | 1094.30c |
| 4 | | 1880.40b | 2006.65b | 1943.52b | 2350.7b | 2153.95b | 2252.32b |
| 8 | | 3476.83a | 3408.23a | 2441.03a | 3556.2a | 4015.96a | 3136.06a |
| S.E± | | 123.200 | 74.201 | 73.941 | 179.029 | 74.002 | 90.183 |
| Planting Pattern | | | | | | | |
| Single | | 2051.13b | 1151.80b | 1101.47b | 2567.3b | 2405.26 | 1436.28b |
| Double | | 3454.09a | 3370.83a | 2412.48a | 3951.2a | 3819.82a | 2888.51a |
| S.E± | | 103.013 | 62.054 | 61.185 | 132.005 | 68.011 | 67.119 |
| Interactions | | | | | | | |
| W * PM | | NS | NS | NS | NS | NS | NS |
| W * PP | | NS | NS | NS | NS | NS | NS |
| P M* PP | | NS | NS | NS | NS | NS | NS |
| W*PM*PP | | NS | NS | NS | NS | NS | NS |

Means within a column of any set of treatment group with unlike letter(s) are significantly different at $P \leq 0.05$ using DMRT

DISCUSSION

Influence of Weed Control on Maize Production

The study showed that, hoe weeding at 3 and 6 WAS, application of S-metolachlor + atrazine at 2.64 kg a.i/ha and butachlor at 2.5 kg a.i/ha, significantly increased the vegetative and yield attributes of maize than that of the weedy check treated plots as evident by taller maize plants, higher increase in relative growth rate and total grain yield. Better growth and yield parameters obtained for the hoe weeded plots, were statistically similar as those for S-metolachlor + atrazine at 2.64 kg a.i/ha and butachlor at 2.5 kg a.i/ha. This showed that using these combinations of herbicides will give the same result as hoe weeding constantly to keep the maize plot weed free. This is similar to the findings of (Shebayen, 1998; Ishaya, 2004 and Mahadi, 2011) as they stated that weed competition decrease growth and yield of maize plant.

Influence of Poultry Manure on Growth and Yield of Maize

Poultry manure influenced maize growth and yield parameters significantly. This could be attributed to the ability of the manure in supplying nutrients and organic matter to the soil and improving the soil physical conditions. The result showed that increasing rates of poultry manure gave a significant increase in plant height, relative growth rate and maize grain yield across the locations, years and the means. Plants that received 8 t/ha of poultry manure grew taller than other plants that received 4 t/ha and the shortest plants that received no application of poultry manure, possibly because more concentrated nutrients or minerals were made readily available and easily absorbable by the receiving plants leading to faster growth and development. This finding is in line with the work of Fagimi and Odebode (2007) who reported increased plant height and number of leaves of pepper resulting from application of poultry manure. Higher total grain yield from plots that received 8 t/ha, than plots that received 4 t/ha of manure was possible as more nutrient were released which mineralized rapidly for plant uptake and utilization, which favoured the yield increase. This is similar to the findings of DIPA (2006); Fagimi and Odebode, (2007); Gopinath *et al.*, (2008) and Enujeke *et al.*, (2013).

Influence of Poultry Manure on the Soil for Maize Production

The study also showed that poultry manure is a valuable fertilizer and can serve as alternative to chemical fertilizers in the Northern Guinea Savanna Zone of Nigeria. This is in line with the finding of Obi (1991). Plots treated with poultry manure had lower soil temperature compared with plots with non application of poultry manure. Similarly, application of 8 t/ha of poultry manure in this study increased the moisture content of the soil. This could be related to the improved soil organic matter of plots treated with poultry manure which might have enhanced water retention of the soil and consequently reduced soil temperature of the plots.

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Improvement in nutrient status of poultry manure treated plots implies that poultry manure could be use for soil management for sustainable production of maize. In support of this, (Boateng *et al.*, (2006); Tayebbeh *et al.*, (2010) reported that Farm Yard Manure (F.Y.M) increased soil P.H and micronutrients of the soil. Mahadi (2011) reported that cow dung manure improved surface P.H. and other nutrients and yield of maize. Aliyu (2002) stated that poultry manure had significant effect on the yield and composition of pepper.

Influence of Planting Pattern on Growth and Yield of Maize

The results from this studies also, showed that planting pattern significantly affect the growth and yield parameters of maize. Plant height was significantly affected by planting pattern, more especially with the double planting pattern, than the single planting pattern and this was possible due to optimum utilization of soil and other environmental resources by the maize plant. The result from this study on grain yield also revealed that grain yield was significantly higher with double planting pattern. This result are supported by Saberali (2007) who verified that number of cobs and number of row per cob are the most important yield components in response to planting pattern in maize. Double planting pattern produced more yield than single pattern. Sangoi (2001) reported that grain yield of maize was significantly higher with double planting pattern than in single row and this was closely related to the environment in light interception during critical period of grain set. The lowest grain yield was obtained at single row pattern, because of lower grain per cob. (Ali *et al.*, 2013) reported that single row significantly affect the main grain yield per plant and 100 seed weight.

CONCLUSION AND RECOMMENDATION

Based on these findings, application of S-metolachlor + atrazine at 2.64 kg a.i/ha, butachlor at 2.5 kg a.i/ha can serve as an alternative to hoe weeding and significantly reduced mean weed population and increased the growth and yield of maize than that of weedy check plots. Use of poultry manure in maize production is recommended as it improved the fertility of the soil thereby increased growth as well as yield of maize. Poultry manure also increased plant height, relative growth rate and maize grain yield. Similarly, double plating pattern (double row per ridge) could also be adopted for effective weed suppression than single planting pattern (single row per ridge) and increased growth and yield of maize.

Conflict of interest

Authors have declared that no competing interest exist in the paper.

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