Growth and production of maize with several land tillage system and plant density treatments

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Abstract. Tillage system is one of the land preparation activities which aims to create suitable environmental conditions for plant growth. The study aimed to determine the growth and production of hybrid corn with several tillage system and seeds density. The study was arranged with a split design experiment. The main plot was tillage system which consisted of no tillage (NT), minimum tillage (MiT), maximum tillage (MaT). Subplot was the seeds density (number of seeds per hole) consisting of one seed, two seeds, and three seeds. The total of 9 treatment combinations were repeated 3 times, making a total of 27 experimental units. The results showed that perfect tillage treatment gave the highest yield of unpeeled cobs (218.30 g), cob diameter (44.10 mm) and production per hectare (6.00 tons).

1. Introduction

Soil has an important function of terrestrial ecosystems that determine balance between physical, chemical and biological factors. The main component of soil consists of inorganic minerals, sand, dust, clay, organic materials resulting from decomposition of soil biota, bacteria, fungi, algae, nematodes and so on [1].

Soil quality is influenced by land management activities, when the treatment is improper, it will cause soil quality to decrease and hence reduce crop production. In order to increase the production of maize on dry land, proper land tillage is necessary [2]. In general there are three objectives of soil tillage, namely weed controlling, organic matter and soil mixing and soil physical properties improvement [3]. According to its intensity, soil tillage can be divided into three types, namely no tillage, minimum tillage and maximum tillage. In conservation tillage systems there are two commonly used systems namely without minimum tillage and tillage [4]. According to Putte [5], soil tillage can change the soil structure resulting in increased soil resistance to the penetration of vertical groundwater movements or more commonly called soil infiltration power. This can cause water to pool in the surface which can then turn into a surface run (surface run off). Therefore a tillage system is required to suppress the amount of surface runoff and erosion. Banuwa's research [6] also showed that soil conservation measures, especially the in-line-with-contours planting, very effectively in suppressing the amount of surface runoff and erosion rates without reducing crop production.

Plant population in an area is influenced by the number of plants per planting hole [7]. Adjusting the number of seeds per planting hole is a simple way to regulate the light received by plants as they grow. In simple calculation, an increase yield per unit area should be achieved with high density, due to the maximum use of light at the beginning of growth. But as the plants advance their growing
phase, eventually each parent plant decreases due to light competition and other growing factors, in this case the response is shown by decreasing of plants part or the overall plant size [8]. According to Sirappa [9], the use of seeds per planting hole affects growth because it is directly dealing with competition between plants within same family (intraspecific). Plant density greatly influences crop yield or production. This is related to the level of competition between plants in obtaining light, water, space, and nutrients. Plant density can be regulated by using the right amount of seeds. The use of the right amount of seeds will result in favourable final yield, in addition to a more efficient in land use. The number of 1 seed and 2 seeds statistically may not show any real difference. Indrayanti [10] stated that the treatment of 3 seeds can cause competition between plants, in particular for the light factor especially when the plants are in large numbers. Competition between the same species causes light competition to become heavier due to the heavy shade effect, while competition between different species is expressed by increasing number and size of plants of the dominant species.

2. Methodology
The study was conducted with Split Plot Design, the experiment had 2 factors: the tillage system as the main plot (PU) consisting of no tillage (O1), minimum tillage (O2) and maximum tillage (O3). The sub plots were number of seeds per hole, consisting of 1 seed / hole (j1), 2 seeds / hole (j2) and 3 seeds / hole (j3). This research used a land area of 22 m x 12 m with a plot size of 3.5 m x 2 m. The main plot consists of 9 sub plots. Each treatment in the subplots had 3 replications making a total of 27 experimental plot units. The plant population per plot was 945 plants, hence the experiment used a total number of seeds of 1,890.

2.1. Tillage systems
The main plot consisted of three tillage systems, each application of the system is described as follows:

2.1.1. No tillage; it was done by planting without processing such as, reversing and loosening the soil first, only cleaning the weeds and making holes for seed planting.

2.1.2. Minimum tillage; was a land management that was just adjusted to the needs of planting and soil conditions, soil turning and loosening was carried out only around the area of planting spots. Minimum tillage aimed to prevent the land from becoming saturated.

2.1.3. Maximum / perfect tillage. Land management was performed by processing all area of planting completely. The activities were soil turning and loosening with a tractor aiming to create an environment where seeds could be planted more easily.

2.2. Seeds planting
Corn seeds used in this experiment were hybrid seeds. Before planting, the seeds were immersed for 20-30 minutes so that during planting the seeds can adapt to moist soil. Seed planting was carried out by drilling or making planting holes as deep as 3-4 cm with a spacing of 70 x 25 cm. Number of seeds planted according to treatment. Seed planting was followed by pesticide application before the seeds were covered with soil.

3. Results and discussion
Several variables of observation representing growth and production are presented in the following tables and figures.
Figure 1. Plant height observed 88 days after planting (DAP)

Variance analysis showed that tillage system, number of seeds per hole and interaction of both did not significantly affect plant height observed 88 days after planting (DAP). Figure 2 shows that the minimum tillage (O2) treatment and 1 seed per hole (j1), the highest average plant height was 216.76 cm. Whereas the minimum tillage (O2) and seeds 3 per hole (j3) showed the lowest average plant height was 211.76 cm.

Perfect tillage causes the soil to become crumble enough to be capable in delivering water to the rhizosphere of the corn quickly. According to Dwidjoseputro [11] consistent water availability helps plant growth as indicated by the increasing size and weight of corn cobs. This reflects the increase in protoplasm that occurs due to increased cell size.

Table 1. Weight of unpeeled cobs (g)

| Number of seeds per hole | Soil tillage system | Average |
|--------------------------|---------------------|---------|
|                          | O1                  | O2      | O3      |         |
| j1                       | 190.10              | 228.29  | 231.86  | 216.75  |
| j2                       | 209.33              | 209.62  | 221.43  | 213.46  |
| j3                       | 219.48              | 199.33  | 201.62  | 206.81  |
| Average                  | 206.30<sup>b</sup>  | 212.41<sup>ab</sup> | 218.30<sup>a</sup> |         |

LSD 0.05 6.45

Notes: The numbers followed by the same letter indicates non significant difference in the LSD<sub>0.05</sub> test.

Variance analysis showed that the tillage sytem and number of seeds had a very significant effect, yet the interaction of both had no significant effect on the weight of unpeeled cob. Table 1 shows that the highest average weight of unpeeled cob was achieved by the maximum tillage treatment (O3) i.e. 218.30 g. It was not significantly different from the minimum tillage treatment (O2), but significantly different from the treatment without tillage (O1). The lowest weight of peeled cob was found in the treatment of no tillage (O1) that was 206.30 g.
Variance analysis showed that the tillage system, the number of seeds, and the interaction of both treatments had no significant effect on the weight of the peeled cobs (g). Figure 2 shows that the highest average weight of peeled cobs was achieved by maximum/perfect tillage treatment (O3) and 1 seed per hole (j1) i.e. 186 g. While the minimum tillage (O2) and 3 seeds per hole (j3) showed the lowest average weight of peeled cobs that was 162 g.

Variance analysis showed that tillage treatment, number of seeds and interaction of both had no significant effect on cob length. Figure 4 shows that the maximum/perfect soil tillage (O3) and 2 seeds per hole (j2) showed the highest average cob length of 18.74 cm. Whereas the maximum/perfect soil tillage (O3) and 3 seeds per hole (O3) gave the lowest average cob length of 17.11 cm.
Table 2. Diameter of cobs (mm)

| Number of seeds per hole | Soil tillage system | Average |
|-------------------------|---------------------|---------|
|                         | O1                  | O2      | O3      |
| j1                      | 42.71               | 42.80   | 43.97   | 43.16   |
| j2                      | 43.96               | 43.25   | 44.18   | 43.80   |
| j3                      | 43.54               | 42.49   | 44.15   | 43.39   |
| Average                 | 43.40               | 42.85   | 44.10   | 43.39   |

LSD 0.05

Notes: The numbers followed by the same letter indicates non significant difference in the LSD 0.05 test.

The variance analysis showed that the soil tillage treatment had a significant effect while the the number of seeds and interactions between both factors did not significantly affect the diameter of the cobs. Table 2 shows that the highest average cob diameter was obtained by maximum soil tillage (O3) which is 44.10 mm. It was not significantly different from no tillage system (O1) but significantly different from minimum tillage (O2) which had the lowest average diameter of 42.85 mm.

Perfect soil tillage can improve plant's capability for water absorption. It also lead to increased soil fertility. Rachman, Latifa, & Nurida [12] revealed a consistent idea that soil tillage and good land management in maize cultivation gave a better effect on the corn cobs when compared to planting area without tillage. This was due to the fact that soil tillage can affect the amount of mycorrhizal spores in the soil and affect the yield of corn.

![Figure 4. Weight of 1000 grains (g)](image)

The analysis of variance showed that the tillage treatment, the number of seeds and their interaction did not significantly affect the weight of 1000 seeds. Figure 4 shows that the maximum soil tillage treatment (O3) with 1 seed per hole (j1) gave the highest average weight of 1000 grains i.e. 372.67 g. Whereas the no soil tillage (O3) with 3 seeds per hole (j3) gave the lowest average weight of 1000 grains which was 347.67 g.
Figure 5. Yields per plot (kg)

Variance analysis showed that soil tillage treatment and number of seeds as well as the interaction of the two did not significantly affect the production (yields) per plot. Figure 5 shows that maximum soil tillage treatment (O3) and 3 seeds per hole (j3) produced the highest yields per plot i.e. 3.42 kg. Whereas in the minimum soil tillage (O2) and 3 seeds treatment gave the lowest average production per plot which was 2.32 kg.

Table 3. Production per hectare (ton)

| Number of seeds per hole | Soil tillage system | Average |
|--------------------------|---------------------|---------|
|                          | O1                  | O2      | O3      |
| j1                       | 5.58                | 5.78    | 6.16    | 5.84 |
| j2                       | 5.79                | 5.34    | 6.11    | 5.75 |
| j3                       | 5.67                | 4.92    | 5.74    | 5.44 |
| Average                  | 5.68\(^b\)          | 5.35\(^c\) | 6.00\(^a\) |
|                          | LSD 0.05            |         | 0.30    |

Notes: The numbers followed by the same letter indicates non significant difference in the LSD\(_{0.05}\) test.

The variance analysis showed that soil tillage treatments had a very significant effect on production per hectare, while the number of seeds treatment and the interaction of the two factors had no significant effect on production per hectare. Table 3, shows the highest production per hectare was achieved by maximum soil tillage treatment (O3) which was 6.00 tons per hectare. It was significantly different from no soil tillage treatment (O1) and minimum soil tillage treatment (O2) with lowest average production per hectare of 5.35 t / ha. Setyawati [13] also had similar results where the maximum soil tillage produced corn production of 7.22 tons / ha, while the minimum soil tillage produced 6.96 t / ha.

Number of seeds in this study did not significantly affect the production were also found by Masdar [14] and Jasman [15]. They presume the number of one, two and three seeds can not provide optimal results in increasing the production of corn as it is more dependant on other factors such as the environment and farming inputs.
4. Conclusion
There was no interaction between the soil tillage system and the number of seeds in planting holes on the growth and production of corn. Perfect maximum soil tillage gave the best results in unpeeled cobs (218.30 g), cobs diameter (44.10 mm) and production per hectare (6.00 tons). As an individual factor the number of seeds in planting hole did not affect the growth and production of the corn.

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