Growth analysis of some maize cultivars on weedy condition

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Abstract. This research purpose was to study the influence of weed on the growth process of some maize cultivars. It was held from March to July 2016 in Banguntapan, Bantul, Yogyakarta and Plant Production Laboratory, Agriculture Faculty, Gadjah Mada University. The experiment design was split plot based on randomized complete block design. The corn cultivars as the main plot consisted of Bisi 18, Bisi 2, Pertiwi 3, NK 22, NK 33, DK 771, DK 95, P 23, Bima 19 uri, Bisma, and Sukmaraga while the presence of weed as a sub-plot consisted of non-weedy and weedy. Data were analyzed using variance analysis (ANOVA) and Duncan Multiple Range Test (DMRT) of 5 % significant. The results showed that there was an interaction between maize cultivar and weed presence to the leaf area index and specific leaf weight on 6 week after planting (WAP). Weed did not decrease net assimilation rate on 4-6 WAP and 6-8 MST. Weed also did not decrease specific leaf weight. Weed reduce d leaf area index and biomass dry weight on 6 and 8 WAP and crop growth rate on 4-6 WAP and 6-8 WAP. DK 771 and Sukmaraga produced the highest dry weight.

1. Introduction
One of the plant disrupting organisms that can cause great harm to maize growth and yield is weeds. Weeds can degrade plant growth and yield through competition and alelopathy [1]. Competition can lead to a reduction in plants growth rate and reproductive capacity [2]. Alelopathy is a biochemical reaction between two or more plants that produces chemicals and affects the physiological processes of plants or surrounding organisms [3]. These two factors, in nature will exert influence together and difficult to separate so-called interference [4].

The presence of weeds can lead to stress due to competition to obtain nutrients, water and sunlight. In a water deficit stress condition, silking the possibility of delayed and affecting the interval between silking and tasseling. The greater the value of anthesis silking interval (ASI), the smaller the synchronization of flowering and the pollination is inhibited thus lowering the yield [5]. The presence of weeds in maize will also affect ASI. According to Reid et al [6], delayed weed control in the early stages of maize growth can prolong ASI. Increase in maize population and X. strumarium L. also caused a delay in the appearance of female flowers, lowering the yield and components of yield [7].

There are several types of maize cultivated by farmers in Indonesia, namely local varieties, composites, and hybrids. Basically, corn is classified into two free-flowing varieties: (un-hybrid) and hybrid varieties [8]. Maize cultivars have different characteristics. Each type has different morphological characteristics. Each maize cultivar has physiological properties such as net assimilation rate (LAB), crop growth rate (LPT), relative growth rate (LPR), and specific leaf weight (SLW). The morphological and physiological characteristics of each variety will affect the variety's ability to respond
to existing environmental conditions and affect its ability to compete with weeds. According to Mohammadi [9], six cultivars, namely KSC 302, KSC 500, KSC 647, KSC 700, and KSC 704, resulted in diverse LAB, LPT, LPR, and SLW, and these parameters also affected the ability to compete against weeds. The ability to compete will affect the resilience of maize to weeds. Based on the description, it is necessary to study how weeds affect the growth process of some maize cultivars.

2. Material and methods
The research was done from March to August 2016 in Banguntapan, Bantul, Yogyakarta and Plant Production Laboratory of Agriculture Faculty of Gadjah Mada University. The experiment design in this study was a split plot based on randomized complete block design. The maize cultivars as the main plot consisted of Bisi 18, Bisi 2, Pertiwi 3, NK22, NK 33, DK 959, DK771, DK 95, P23; Bima 19 uri, Bisma and Sukmaraga, while the presence of weed as a sub-plot consisted of non-weedy and weedy.

The observed parameters were leaf area index, net assimilation rate, specific leaf weight, crop growth rate, and dry weight of biomass. Data analysis used variance analysis (ANOVA) and Duncan Multiple Range Test (DMRT) of 5% significant [10].

3. Results and discussion

3.1. Leaf area index
Leaves are an important part of the plant and in general each plant has a large number of leaves [11]. Leaf density is closely related to plant populations or planting distances. The relationship of leaf area index with plant biomass production is entwined through the process of photosynthesis [12]. The optimum value of leaf area index is a leaf area index that provides the highest biomass production and is estimated at about 5 in many plants [13].

The results of analysis varians showed no interaction between cultivars and weeds to the leaf area index of at the age of 4, 6, and 8 WAP (Tabel 1). Cultivars have a significant effect on 4 WAP and 8 WAP, while weeds have a significant effect on the leaf area index at 6 and 8 WAP.

| Treatment | 4 WAP | 6 WAP | 8 WAP |
|-----------|-------|-------|-------|
|           | NW    | W     | Average | NW    | W     | Average | NW    | W     | Average |
| Cultivars |       |       |         |       |       |         |       |       |         |
| Bisi 18   | 1.38  | 0.99  | 1.18 c   | 4.85  | 3.72  | 4.28 a  | 3.61  | 3.51  | 3.56 c  |
| Bisi 2    | 1.39  | 1.20  | 1.30 bc  | 4.86  | 4.02  | 4.44 a  | 4.88  | 3.53  | 4.21 ab |
| Pertiwi 3 | 1.44  | 1.28  | 1.36 bc  | 4.77  | 3.91  | 4.34 a  | 4.47  | 3.96  | 4.22 ab |
| NK22      | 1.49  | 1.18  | 1.33 bc  | 4.27  | 3.98  | 4.13 a  | 3.97  | 3.63  | 3.80 bc |
| NK33      | 1.83  | 1.67  | 1.75 a   | 4.48  | 4.34  | 4.41 a  | 4.42  | 3.50  | 3.96 a-c|
| DK959     | 1.45  | 1.14  | 1.29 bc  | 4.29  | 3.71  | 4.00 a  | 3.89  | 3.31  | 3.60 c  |
| P23       | 1.52  | 1.28  | 1.40 bc  | 4.65  | 3.69  | 4.17 a  | 4.67  | 3.93  | 4.30 ab |
| DK95      | 1.46  | 1.20  | 1.33 bc  | 4.02  | 3.63  | 3.82 a  | 3.65  | 3.26  | 3.45 c  |
| DK771     | 1.59  | 1.31  | 1.45 b   | 4.76  | 3.83  | 4.29 a  | 4.50  | 4.02  | 4.26 ab |
| Bima 19 Uri| 1.44  | 1.25  | 1.35 bc  | 5.12  | 4.12  | 4.62 a  | 4.77  | 3.70  | 4.23 ab |
| Bisma     | 1.84  | 1.53  | 1.68 a   | 4.49  | 4.29  | 4.39 a  | 4.42  | 3.53  | 3.97 a-c|
| Sukmaraga | 1.38  | 1.31  | 1.35 bc  | 4.53  | 3.95  | 4.24 a  | 4.97  | 3.88  | 4.42 a  |
| Weed      | 1.52 a| 1.28 a| (-)      | 4.59 a| 3.93 b| (-)     | 4.35 a| 3.65 a| (-)     |

Remarks: Numbers followed by the same letter indicate there is no significant different at the 5% level; (-): no interaction; NW: non-weedy; W: Weedy

At 4 WAP, the highest leaf area index was found in NK 33 and Bisma, while the lowest leaf area index was found in Bisi 18 which did not differ significantly from Bisi 2, Pertiwi 3, NK 22, DK 959, P23, DK 95, NK22, NK 33, DK 959, DK771, Bisma, and Sukmaraga, while the presence of weed as a sub-plot consisted of non-weedy and weedy.
23, DK 95, Bima 19 Uri, and Sukmaraga. There was no difference in the leaf area index at 6 WAP in all maize cultivars studied. At 6 WAP, the leaf area index increased, but at 8 WAP there was a decrease in the leaf area index except in cultivars P 23 and Sukmaraga. At 8 WAP, the highest leaf area index was found in sukmaraga cultivars which was not different from Bisi 2, Pertwi 3, NK 33, P 23, DK 771, Bima 19 Uri, and Bisma. The lowest leaf area index was found in DK 95, DK 959, and Bisi 18 but they were not different from NK 22, NK 33, and Bisma (Table 1).

Starting the growth of 6 WAP up to 8 WAP, weeds are able to suppress the leaf area index. The leaf area index in non-weedy condition is greater than in weedy condition. According to [14], weed interference is very influential to Phaseolus vulgaris L. Plant biomass decreases more and more as the length of the weeds period. Weed interference also degrade leaf area index, but the decline is not particularly striking at the beginning of growth because weed density is still low. The leaf area index is also decreased due to weed interference [15].

3.2. Specific leaf weight

The amount of plant ingredients (carbohydrates) allocated to each part of the plant are varies. The use of plant biomass for leaf formation changes with plant age and differs between plant types [12]. The results of varians analysis showed no interaction between cultivars and weeds to specific leaf weight (Table 2). Cultivars had a significant effect on 4 WAP, while at 6 and 8 WAP had no significant effect. Weeds also had no significant effect on the specific leaf weight at 4, 6, and 8 WAP.

### Table 2. Specific Leaf Weight (g.m⁻²) of some maize cultivars in non-weedy and weedy condition

| Treatment | Plant Age (WAP) |
|-----------|-----------------|
|           | 4 WAP | 6 WAP | 8 WAP |
|           | NW    | W     | Average | NW    | W     | Average | NW    | W     | Average |
| Bisi 18   | 0.37  | 0.35  | 0.36  | a     | 0.48  | 0.44  | 0.46  | a     | 0.64  | 0.51  | 0.58  | a |
| Bisi 2    | 0.35  | 0.36  | 0.36  | a     | 0.42  | 0.44  | 0.43  | a     | 0.43  | 0.50  | 0.46  | a |
| Pertwi 3  | 0.35  | 0.40  | 0.37  | a     | 0.47  | 0.47  | 0.47  | a     | 0.49  | 0.53  | 0.51  | a |
| NK22      | 0.39  | 0.36  | 0.37  | a     | 0.48  | 0.45  | 0.46  | a     | 0.47  | 0.51  | 0.49  | a |
| NK33      | 0.35  | 0.34  | 0.34  | ab    | 0.45  | 0.46  | 0.45  | a     | 0.49  | 0.52  | 0.51  | a |
| DK959     | 0.35  | 0.39  | 0.37  | a     | 0.49  | 0.46  | 0.47  | a     | 0.53  | 0.49  | 0.51  | a |
| P23       | 0.35  | 0.35  | 0.35  | ab    | 0.42  | 0.45  | 0.43  | a     | 0.46  | 0.51  | 0.49  | a |
| DK95      | 0.36  | 0.33  | 0.34  | ab    | 0.46  | 0.53  | 0.49  | a     | 0.54  | 0.47  | 0.51  | a |
| DK771     | 0.38  | 0.37  | 0.38  | a     | 0.46  | 0.45  | 0.45  | a     | 0.55  | 0.51  | 0.53  | a |
| Bima 19 Uri | 0.33  | 0.34  | 0.33  | ab    | 0.41  | 0.41  | 0.41  | a     | 0.45  | 0.49  | 0.47  | a |
| Bisma     | 0.32  | 0.30  | 0.31  | b     | 0.43  | 0.43  | 0.43  | a     | 0.44  | 0.49  | 0.47  | a |
| Sukmaraga | 0.37  | 0.31  | 0.34  | ab    | 0.45  | 0.45  | 0.45  | a     | 0.47  | 0.50  | 0.48  | a |

Weed: 0.36a 0.35a (-) 0.005a 0.005a (-) 0.50a 0.50a (-)

Remarks: Numbers followed by the same letter indicate there is no significant different at the 5% level; (-): no interaction; NW: non-weedy; W: Weedy

At 4 WAP, the specific leaf weight was larger in Bisi 18, Bisi 2, Pertwi 3, NK 22, DK 959, and DK 771, but was not different from NK 33, P 23, DK 95, Bima 19 Uri, and Sukmaraga. The lowest specific leaf weight was in Bisma cultivars and it did not differ significantly from NK 33, P 23, DK 95, Bima 19 Uri, and Sukmaraga. At 6 and 8 WAP, the specific leaf weight produced by all cultivars did not differ significantly, meaning that the specific leaf weight produced by all cultivars was equal. The specific leaf weight on all corn cultivars studied showed an increase with the plant age, although it did not differ significantly between cultivars. Weeds also did not affect the specific leaf weight, so on weedy and non-weedy condition the specific leaf weight were same.
3.3. Net assimilation rate

The net assimilation rate is an average measure of leaf photosynthesis efficiency in a cultivated plant community and the rate of accumulation of dry weight per unit of leaf area per time unit [16]. The results of the variances analysis showed no interaction between cultivars and weeds to net assimilation rates in age plant periods 4–6 WAP and 6–8 WAP (Table 3). Cultivars and weeds also did not have significant effect.

| Treatment  | Plant Age       | NW  | W  | Average | NW  | W  | Average |
|------------|-----------------|-----|----|---------|-----|----|---------|
| Bisi 18    | 4 - 6 WAP       | 0.890 | 0.929 | 0.910 a | 0.301 | 0.411 | 0.356 a |
| Bisi 2     | 4 - 6 WAP       | 0.755 | 0.790 | 0.773 a | 0.462 | 0.319 | 0.391 a |
| Pertiwi 3  | 4 - 6 WAP       | 0.798 | 0.847 | 0.822 a | 0.337 | 0.380 | 0.358 a |
| NK22       | 4 - 6 WAP       | 0.876 | 0.855 | 0.865 a | 0.361 | 0.370 | 0.366 a |
| NK33       | 4 - 6 WAP       | 0.836 | 0.846 | 0.841 a | 0.497 | 0.307 | 0.402 a |
| DK959      | 4 - 6 WAP       | 0.911 | 0.933 | 0.922 a | 0.360 | 0.362 | 0.361 a |
| P23        | 4 - 6 WAP       | 0.714 | 0.770 | 0.742 a | 0.439 | 0.454 | 0.447 a |
| DK95       | 4 - 6 WAP       | 0.832 | 0.833 | 0.833 a | 0.383 | 0.347 | 0.365 a |
| DK771      | 4 - 6 WAP       | 0.864 | 0.763 | 0.814 a | 0.468 | 0.662 | 0.565 a |
| Bima 19 Uri| 4 - 6 WAP       | 0.838 | 0.762 | 0.800 a | 0.347 | 0.365 | 0.356 a |
| Bisma      | 4 - 6 WAP       | 0.767 | 0.719 | 0.743 a | 0.354 | 0.272 | 0.313 a |
| Sukmaraga  | 4 - 6 WAP       | 0.990 | 0.904 | 0.947 a | 0.545 | 0.472 | 0.508 a |
| Weed       | 4 - 6 WAP       | 0.839 a | 0.829 a | ( - ) | 0.404 a | 0.393 a | ( - ) |

Remarks: Numbers followed by the same letter indicate there is no significant different at the 5% level; (-): there is no interaction; NW: non-weedy; W: Weedy

In the 6–8 WAP period, there was a decrease in the rate of net assimilation in all cultivars (Table 3). The maize cultivars studied showed a net assimilation rate that did not differ significantly, meaning that the net assimilation rate in all maize cultivars was the same. Likewise, the presence of weeds also had no significant effect on net assimilation rate, so that net assimilation rate in weedy condition was equal to the net assimilation rate in non-weedy condition.

3.4. Crop growth rate

The crop growth rate represents an increase in dry weight in the plant community per unit of soil area over a time period [16]. The results of the variances analysis showed no interaction between cultivars and weeds to the crop growth rate. Maize cultivars had no significant effect, while weeds had a significant effect on the crop growth rate.

Based on Table 4, crop growth rates in periods 4–6 WAP and 6–8 WAP in all cultivars do not differ significantly. Weeds are able to suppress the crop growth rate so that in non-weedy condition, crop growth rate is higher than in weedy condition. There was a decrease in the crop growth rate from a period of 4–6 WAP. This indicates that an increase in dry weight in the plant community per unit of soil area in the period 6–8 WAP was lower than the previous period.
Table 4. Crop Growth Rate (g.dm\(^{-2}\).week\(^{-1}\)) of corn cultivars in non-weedy and weedy condition

| Treatment          | Agr Plant | 4 - 6 WAP | 6 - 8 WAP |            |            |
|--------------------|-----------|-----------|-----------|------------|------------|
|                    | NW        | W         | Average   | NW         | W          |
| Cultivar           |           |           |           |            |            |
| Bisi 18            | 242.173   | 186.554   | 214.363   | a          | 139.482    | 140.12 a    |
| Bisi 2             | 209.119   | 184.500   | 196.810   | a          | 222.470    | 117.530 a   |
| Pertiwi 3          | 220.161   | 196.137   | 208.149   | a          | 162.238    | 140.762 a   |
| NK22               | 229.905   | 192.244   | 211.074   | a          | 163.714    | 134.952 a   |
| NK33               | 247.988   | 235.982   | 241.985   | a          | 216.857    | 170.00 a    |
| DK959              | 237.804   | 200.298   | 219.051   | a          | 150.732    | 140.12 a    |
| P23                | 196.935   | 174.292   | 185.613   | a          | 199.024    | 178.79 a    |
| DK95               | 210.518   | 183.494   | 197.006   | a          | 144.565    | 135.12 a    |
| DK771              | 249.369   | 178.542   | 213.955   | a          | 208.792    | 227.71 a    |
| Bima 19 Uri        | 232.137   | 183.625   | 207.881   | a          | 176.655    | 160.02 a    |
| Bisma              | 225.970   | 192.149   | 209.060   | a          | 154.375    | 135.12 a    |
| Sukmaraga          | 258.018   | 216.911   | 237.464   | a          | 250.857    | 214.92 a    |
| Weed               | 230.008   | 193.727 b | (-)       | 182.480 a  | 149.012 b  | (-)         |

Remarks: Numbers followed by the same letter indicate there is no significant different at the 5% level; (-): there is no interaction; NW: non-weedy; W: Weedy

3.5. Dry weight of biomass

Dry weight of biomass is one indicator of plant growth. The increase in dry weight of the plant during growth indicates the on going growth. The results of the varians analysis showed no interaction between corn cultivars and weeds at 4, 6, and 8 WAP. At 6 WAP, maize cultivars were not significantly different, whereas weeds were significantly different. At 8 WAP, cultivars and weeds had a significant effect on the dry weight of biomass, but no interaction occurred.

At 4 WAP, the biggest dry weight of biomass was generated by cultivars NK 33 and it was not different from DK 771 and Bisma. The lowest dry weight of biomass was produced by Bisi 18 and Bima 19 Uri cultivars and it was no different from Bisi 2, Pertiwi 3, NK 22, DK 959, P23, DK 95, and Sukmaraga. At 6 WAP, all maize cultivars produced a dry weight of biomass that was not different significantly.

At the age plant of 8 WAP, DK 771 cultivar produced the larger dry weight but was not different from Sukmaraga and NK 33. The lowest dry weight of plants was produced by Bisi 18, DK 95, and Bisma, but was not different from Bisi 2, Pertiwi 3, NK 22, DK 959, P 23, and Bima 19 Uri. The amount of dry weight of the produced plant is also influenced by genetic and environmental factors.

At the period of 6 and 8 WAP, the presence of weeds was able to suppress the formation of dry weight of biomass, so that in weedy condition, biomass dry weight was lower than in non-weedy condition. This can be due to the limitations of the growing factors available to plants that at a later stage, can decreased yields. According to Travlos et al [17], the maximum yield loss is 24 – 34% if *Echinochloa crus-galli* L. appear at an early stage and 9% if *E. crus-galli* L appears after the V4 growth stage. Decrease in biomass dry weight due to weed interference by 24% to 69% [18].
**Table 5.** Dry weight of biomass (g) of maize cultivars in non-weedy and weedy condition

| Treatment | Plant Age | NW  | W   | Average | NW  | W   | Average | NW  | W   | Average |
|-----------|-----------|-----|-----|---------|-----|-----|---------|-----|-----|---------|
| Bisi 18   | 4 WAP     | 12.31 | 8.85 | 10.58 d | d   | 80.12 | 61.08 | 70.60 a | 123.80 | 113.08 | 118.44 a-c |
| Bisi 2    | 6 WAP     | 12.07 | 11.14 | 11.61 ed | ed  | 70.63 | 62.80 | 66.71 a | 146.55 | 110.24 | 128.39 a |
| Pertiwi 3 | 8 WAP     | 12.55 | 11.61 | 12.08 b-d | b-d | 74.20 | 66.53 | 70.36 a | 108.23 | 102.10 | 105.16 ed |
| NK22      |           | 13.23 | 9.85 | 11.54 cd | cd  | 77.61 | 63.68 | 70.64 a | 110.82 | 105.37 | 108.10 b-d |
| NK33      |           | 15.56 | 13.79 | 14.68 a | a   | 84.99 | 79.87 | 82.43 a | 118.39 | 114.88 | 116.63 a-c |
| DK959     |           | 13.77 | 11.16 | 12.46 b-d | b-d | 80.35 | 67.25 | 73.80 a | 119.19 | 104.85 | 112.02 b-d |
| P23       |           | 13.21 | 10.27 | 11.74 cd | cd  | 68.35 | 59.07 | 63.71 a | 131.42 | 108.50 | 119.96 a-c |
| DK96      |           | 13.43 | 10.85 | 12.14 b-d | b-d | 72.37 | 62.23 | 67.30 a | 117.51 | 106.22 | 111.86 b-d |
| DK771     |           | 15.02 | 12.56 | 13.79 ab | ab  | 84.84 | 62.55 | 73.69 a | 128.84 | 114.14 | 121.49 ab |
| Bima 19 Uri |         | 12.23 | 9.22 | 10.72 d | d   | 77.23 | 60.63 | 68.93 a | 110.87 | 86.42 | 98.65 d |
| Bisma     |           | 14.97 | 12.06 | 13.51 a-c | a-c | 78.24 | 65.87 | 72.05 a | 128.73 | 91.37 | 110.05 b-d |
| Sukmaraga |           | 12.70 | 10.97 | 11.84 b-d | b-d | 84.95 | 71.71 | 78.33 a | 148.64 | 108.17 | 128.41 a |
| Weed      |           | 13.42a | 11.03a | ( -) | ( -) | 77.82a | 65.27b | ( -) | 124.42a | 105.44b | ( -) |

Remarks: Numbers followed by the same letter indicate there is no significant different at the 5% level; ( -): there is no interaction; NW: non-weedy; W: Weedy

### 4. Conclusion

Some of the conclusions from this study are: (a) there was an interaction between maize cultivar and weed presence to the leaf area index and specific leaf weight on 6 week after planting (WAP); (b) Weed did not decrease net assimilation rate in the period on 4 - 6 WAP, and 6 - 8 WAP. Weed also did not decrease specific leaf weight; (c) Weed reduced leaf area index on 6 and 8 WAP, crop growth rate on 4 - 6 WAP and 6 - 8 WAP and dry weight of biomass on 6 WAP and 8 WAP; (d) DK 771 and Sukmaraga produce dry weight of plant bigger than others.

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