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Abstract. This research aimed to identify the effect of weed and nitrogen dose on growth of some corn cultivars. The field research was carried out in Banguntapan, Bantul, Yogyakarta, and arranged using Randomised Completely Block Design with three replications. The treatment factors consisted of cultivars (Bisi 18, NK 33, DK 95 and Sukmaraga), weed (weed-free and weedy) and nitrogen dose (25, 150 dan 275 kg N ha^{-1}). Data were analyzed using analysis of variance, continued with Duncan's Multiple Range Test at significant level of 5%. The results showed that there was no interaction between cultivar, weed, and nitrogen dose on plant height, number of leaves, stem diameter, leaf length, leaf width, and angle of the leaves. The least number of leaves on 10 weeks after planting was Sukmaraga. Weed suppressed the plant height, number of leaves, stem diameter, leaf length, leaf width and angle of the leaves, thus the plant which growth on weed-free was higher than on weedy. Nitrogen dose of 25 kg N ha^{-1} produced the shortest plant, the least number of leaves and the smallest stem diameter compared to the nitrogen dose of 150 kg N ha^{-1} and 275 kg N ha^{-1}.

1. Introduction

Corn is a food crop commodity with multi-function such as food, industrial raw materials, farmers' sources of income and alternative fuels or biofuels [1-2]. The demand for corn has increased along with the population growth. National corn production is still low, although tends to increase every year. In 2016, national corn production increased by 18.23% from previous year [3]. National corn production is determined by corn production of at farmer level [2]. Diversity in the use of varieties, tillage, plant population, cropping patterns, cultivation technology and socio-economic conditions of farmers led to the diversity of corn productivity [4].

Availability of nutrients and the presence of weed become the limiting factors in corn production. Corn plants need at least 13 nutrients, particularly N, P, and K are needed in more quantities. Some factors influence nutrient availability in the soil including the total supply of nutrients, soil moisture and aeration, soil temperature, and soil physical and chemical properties [5].

The presence of weed can cause a decrease in crop yield and seed quality. Weed control at the beginning of the season is very important [6]. Weed also cause competition to get nutrients. The amount of competition depends on the amount of nutrients available in the soil and the number of plants involved in the competition. Nitrogen is the first nutrient which limit the weed and crop

competition. The root depth and root surface area per plant determine the ability to obtain resources and competitiveness to obtain nitrogen [7].

Apart from competition, weed is also a harm plants through allelopathy. Competition for the availability of growth factors needed and allelopathy, are difficult to separate so that interference is needed, which includes both factors [8]. This study aimed to identify the effect of the presence of weed and nitrogen dose on the growth of several corn cultivars.

2. Materials and methods

This research was conducted in the experimental field of Universitas Gadjah Mada, Banguntapan, Bantul, Yogyakarta. The study used a complete randomized block design with 3 factors and repeated three times. The first factor was corn cultivars (Bisi 18, NK 33, DK 95 and Sukmaraga), the second factor was the presence of weed (weed-free and weedy), the third factor was the nitrogen dose (25, 150 kg N ha^{-1} and 275 kg N ha^{-1}).

The parameters observed included number of leaves, stem diameter, leaf length, leaf width, leaf angle and plant height. The data were done analysis of variance (ANOVA) at the level of 5% and if there is a significant difference continued with Duncan's test of 5% significant.

3. Results and discussion

3.1. Number of leaves

The leaf is important plant organ for CO_2 uptake, processing of food substances, transpiration and respiration [9]. The number of leaves affect the ability to capture the sunlight which subsequently affect the rate of photosynthesis. There was no interaction between cultivars, weed and nitrogen dose on the number of corn leaves at 4, 6 and 8 weeks after planting (WAP). The weed and nitrogen had significant effects, but the interaction between these factors only occurred at 4 WAP (Table 1). At 10 WAP, there was no interaction between cultivars, weed and nitrogen. Cultivars, weed and nitrogen have significant effects on the number of leaves.

At 4, 6 and 8 WAP, there was no difference on number of leaves produced in Bisi 18, NK 33, DK 95 and Sukmaraga cultivars. At 10 WAP, Bisi 18 and DK 95 cultivar produce the more leaves than Sukmaraga (Table 1).

It is generally accepted that weed can suppress the leaf growth. Starting from 4 to 10 WAP, the presence of weed lessened the number of corn leaves compared with weed-free condition. The weeds inhibit plant growth and yield, as it causes competition to get the same growth factor and allelopathy. Allelopathy is a direct or indirect influence from one plant to another, including microorganisms, both stimulating and inhibiting the growth by releasing the chemical compounds into the environment [10-11]. Allelopathy is also defined as a biochemical reaction between two or more plants or cultivars that produce chemical and affecting the physiological processes of plants or surrounding organisms [12].

Nitrogen also had a significant effect to the number of corn leaves. At 4 to 10 WAP, increasing nitrogen dose from 25 to 275 kg N ha^{-1} increased the number of leaves. The application of nitrogen at dose of 25 kg N ha^{-1} produces the least leaves than others dose. This indicated that nitrogen sufficiency for plants increase the number of leaves. Weed compete with the corn plant to produce significant elements and eliminate plants in absorbing fertilizer. The application of 250 kg N ha^{-1} in weed-free condition improved the yield and component of corn. At low nitrogen level, the stress caused by weed depressed the growth and yield of the plants, thus it is needed to manage the weed intensively [13]. Application of 60 and 90 kg ha^{-1} nitrogen increased the growth and yield ofn *Abelmoschus esculentus* (L). Moench. Nitrogen application significantly affect plant height if it is applied at 6 WAP at the beginning of the season and 9 WAP at the end of the season. The nitrogen application also affects the number of leaves at 6 and 9 WAP at the beginning and end of the season [14].

Table 1. The number of leaves (blade) of corn cultivars in weed-free and weedy conditions with various dose of nitrogen

Treatments	Age of Plant (weeks)			
	4	6	8	10
Cultivars				
Bisi 18	4.61[a]	5.87[a]	10.11[a]	11.20[a]
NK 33	4.52[a]	5.57[a]	10.28[a]	10.13[b]
DK 95	4.63[a]	5.54[a]	10.61[a]	11.46[a]
Sukmaraga	4.56[a]	5.65[a]	9.59[a]	9.44[c]
Weed				
Weed-free	4.94[a]	6.21[a]	11.07[a]	11.21[a]
Weedy	4.22[b]	5.10[b]	9.23[b]	9.91[b]
Nitrogen dose				
25 kg N ha^{-1}	4.29[b]	5.21[b]	8.83[b]	8.97[b]
150 kg N ha^{-1}	4.71[a]	5.78[a]	10.56[a]	11.15[a]
275 kg N ha^{-1}	4.74[a]	5.99[a]	11.06[a]	11.56[a]
Average	4.58	5.66	10.15	10.56
Interaction	(-)	(-)	(-)	(-)

[a,b,c] Numbers followed by the same letter indicate no significant different at the 5% level; (-): no interaction

Table 2. The effect of cultivars and nitrogen dose on the number of corn leaves at 4 WAP

Cultivars	Nitrogen Dose (Kg N ha^{-1})			Average
	25	150	275	
Bisi 18	4.33[cd]	4.61[abcd]	4.89[ab]	4.61
NK 33	4.16[d]	4.50[bcd]	4.89[ab]	4.52
DK 95	4.51[bcd]	4.62[abcd]	4.78[abc]	4.63
Sukmaraga	4.17[d]	5.11[a]	4.39[bcd]	4.56
Average	4.29	4.71	4.74	(+)

[a, b, c, d] Numbers followed by the same letter indicate no significant different at the 5% level; (+): interaction

At the beginning of 4 WAP, increasing nitrogen dose from 25 to 275 kg N ha^{-1} did not increase number of leaves, except on Sukmaraga cultivar. Application of 25 kg N ha^{-1} resulted in the least number of the leaves in all corn cultivars. At both nitrogen dose of 25 and 275 kg N ha^{-1}, there were no significant differences in the number of leaves produced by all cultivars. At 150 kg ha^{-1}, Sukmaraga cultivar produced the most leaves although it did not differ with Bisi 18 and DK 95, but significantly different with NK 33. Bisi cultivar 18, NK 33 and DK 95 produced the similar number of leaves (Table 2).

3.2. Leaf length, leaf width, leaf angle

Each cultivar has different characteristics including leaf length, width and angle. There was no interaction between cultivars, weed and nitrogen dose on the leaf length. Moreover, there is no differences in leaf length on all cultivars. Both weed and nitrogen dose affect the leaf length (Table 3).

There was no difference on the leaf length of Bisi 18, NK 33, DK 95 and Sukmaraga cultivars, illustrated that the four cultivars had the same leaf length. The leaf length affects the ability of the plant in photosynthesis due to difference in leaf area. Weeds suppress the growth of leaves, as indicated by shorter leaves in the presence of wee rather corn than in weed-free condition. Nitrogen dose also affected the leaf length, where the higher nitrogen dose increased the leaf length. The longest

leaf was obtained at 275 kg N ha^{-1}, while the shortest leaf was resulted by the application of 25 kg N ha^{-1}.

Table 3. Leaf length, leaf width, and leaf angle of corn cultivars in weed-free and weedy conditions with various dose of nitrogen

Treatments	Leaf Length (cm)	Leaf Width (cm)	Leaf Angle (º)
Cultivars			
Bisi 18	74.19[a]	8.24[b]	24.54[b]
NK 33	72.43[a]	9.61[a]	31.57[a]
DK 95	68.44[a]	8.07[b]	30.72[a]
Sukmaraga	70.43[a]	8.44[b]	31.13[a]
Weed			
Weed-free	80.77[a]	9.56[a]	30.11[a]
Weedy	61.97[b]	7.62[b]	28.87[b]
Nitrogen dose			
25 kg N ha^{-1}	61.46[c]	7.72[c]	28.97[a]
150 kg N ha^{-1}	74.17[b]	8.63[b]	30.08[a]
275 kg N ha^{-1}	78.49[a]	9.43[a]	29.42[a]
Average	71.37	8.59	29.49
Interaction	(-)	(-)	(-)

[a, b, c] Numbers followed by the same letter indicate no significant different at the 5% level; (-): no interaction

The cultivars, weed and nitrogen influenced the leaf width, but there was no interaction among the three treatment factors. The NK 33 cultivar resulted the wider leaves than Bisi 18, DK 95 and Sukmaraga. The weeds suppressed the leaf width, where the presence of weed caused leaves tobe narrower than weed-free. Increasing nitrogen dose from 25 kg N ha^{-1} to 275 kg N ha^{-1} increased leaf width. The application of nitrogen at 275 kg N ha^{-1} also produced wider leaves compared to other doses.

There was no interaction between cultivars, weed and nitrogen dose on leaf angle. Cultivars and weed, but not nitrogen dose, affected leaf angle. Leaf angle is more influenced by the genetic factor. The smallest leaf angle was resulted by Bisi 18 and it was significantly different from other cultivars. The NK 33, DK 95 and Sukmaraga cultivars had medium/moderate leaf angle. The leaf angle is classified into 5 classes: very small ($\leq 5^0$), small ($\pm 25^0$), moderate ($\pm \leq 50^0$), large ($\pm \leq 75^0$) and very large ($\pm \leq 90^0$) [15]. Based on leaf angle, Bisi 18 cultivar had the straightest leaf compared to other cultivars. The leaf angle affects the amount of sunlight that can be received by the plants.

3.3. Stem diameter

The stem supports the plant parts, transports water and nutrient, transports the photosynthesis products from top to bottom, as well as a place for food reserves [9]. There was no interaction between cultivars, weed and nitrogen dose on stem diameter. At 4 to 10 WAP, weed and nitrogen dose influenced the stem diameter. There were no differences in stem diameter on all cultivars at 6 to 10 WAP (Table 4).

At 4 WAP, Bisi 18 resulted the smaller stem diameter than other cultivars. At 6 to 10 WAP, there was no difference in the stem diameter for Bisi 18, NK 33, DK 85 and Sukmaraga cultivars. Weed suppressed the growth of the stem from 4 to 10 WAP, thus the stem diameter became smaller than in the weed-free condition. Nitrogen significantly affected stem diameter. Increasing nitrogen dose from 25 kg N ha^{-1} to 275 kg N ha^{-1} increased stem diameter. Nitrogen dose 25 kg N ha^{-1} generated the smaller stem diameter than other nitrogen doses. The largest stem diameter was resulted by application of 275 kg N ha^{-1}. This showed that the adequacy of nitrogen affects the stem growth.

Table 4. Stem diameter (mm) of corn cultivars in weed-free and weedy conditions with various dose of nitrogen

Treatment	Age of plant (weeks)			
	4	6	8	10
Cultivars				
Bisi 18	7.95[b]	15.91[a]	16.97[a]	19.24[a]
NK 33	9.42[a]	15.94[a]	17.02[a]	18.95[a]
DK 95	9.12[a]	14.70[a]	15.73[a]	18.44[a]
Sukmaraga	9.21[a]	15.38[a]	16.64[a]	18.53[a]
Weed				
Weed-free	9.59[a]	17.93[a]	19.10[a]	21.40[a]
Weedy	8.26[b]	13.03[b]	14.07[b]	16.18[b]
Nitrogen dose				
25 kg N ha^{-1}	8.26[b]	13.93[c]	14.98[c]	16.79[c]
150 kg N ha^{-1}	9.24[a]	15.62[b]	16.66[b]	18.85[b]
275 kg N ha^{-1}	9.27[a]	16.90[a]	18.12[a]	20.72[a]
Average	8.93	15.48	16.59	18.79
Interaction	(-)	(-)	(-)	(-)

[a, b, c] Numbers followed by the same letter indicate no significant different at the 5% level; (-): no interaction

3.4. The plant height

Plant height is determined genetically, but also influenced by the environmental factors. During the growth from 4 to 10 WAP, there is no interaction between cultivars, weed and nitrogen on plant height. Weed significantly affected the plant height of 6, 8 and 10 WAP, while nitrogen dose affected the plant height from 4 to 10 WAP (Table 5).

Table 5 showed at 6 to 10 WAP, weed suppressed the plant growth. In the presence of weed, the plant height was shorter than in weed-free condition. Generally, plant height will affect the ability to compete with other plants in obtaining growth factors above the soil surface. The study on two cultivars of *Carthamus tinctoriun* L. planted in spring showed that 5-118 cultivar had better competitiveness against weed as they are higher than 5-154 cultivar [16]. The shorter plants in the presence of weed condition can be caused by competition and through the ability of weed to produce allelochemical. Allelochemical affects all aspects of plant production, including: germination, seedling growth, metabolism and flowering. Allelochemical also affects the photosynthesis, respiration, water potential, nitrification, nutrient absorption, nodulation and nitrogen fixation, lipid metabolism, membrane permeability, nucleic acid and protein, and hormone balance [17]. The various organs of *Echinochloa crusgalli* is a source of allelochemicals. Leaf extract significantly delayed the test species germination (except sunflower) and decreased the germination index compared to control. Maximum inhibition of wheat and maize shoot length was caused by stem extract [18].

Nitrogen dose also affected plant height. Starting from 4 to 10 WAP, application of 25 kg N ha^{-1} produced the shortest plant. Increasing the nitrogen dose from 25 kg N ha^{-1} to 275 kg N ha^{-1} increased the plant height. This showed that the adequacy of nitrogen will affect plant growth. Therefore, the higher dose of nitrogen given, the higher the plant height obtained. However, the plant height at application of 150 kg N ha^{-1} was not significantly different with 275 kg N ha^{-1}. In agreement with this observation, study on rice plant in aerobic conditions indicated that the higher dose of nitrogen improved the plant height, panicle length, seeds per panicle, weight of 1000 seeds, grain yield per grain, straw yield, and N-P-K-uptake [19]. Similarly, in flower cabbage plant, nitrogen fertilizer has a significant effect on 10-30 days after planting (DAP). At 10 and 20 DAP, nitrogen fertilizer of 105 kg N ha^{-1} resulted higher plants than 35 and 70 kg N ha^{-1} [20]. In corn plant grown in sandy soil, the nitrogen fertilizer of 375 kg ha^{-1} produced the higher plant height and seed weight per barrel compared to lower dose of nitrogen fertilizer [21].

Table 5. The plant height (cm) of corn cultivars in weed-free and weedy condition with various dose of nitrogen

Treatments	Age of Plant (Weeks)			
	4	6	8	10
Cultivars				
Bisi 18	72.83[a]	135.02[a]	172.91[a]	188.67[a]
NK 33	80.02[a]	133.69[a]	170.93[a]	187.54[a]
DK 95	73.35[a]	135.04[a]	174.80[a]	190.31[a]
Sukmaraga	76.37[a]	128.73[a]	167.76[a]	177.94[a]
Weed				
Weed-free	77.94[a]	146.27[a]	198.50[a]	213.32[a]
Weedy	73.34[a]	119.97[b]	144.70[b]	158.91[b]
Nitrogen dose				
25 kg N ha^{-1}	70.24[b]	116.46[b]	145.70[b]	162.65[b]
150 kg N ha^{-1}	78.58[a]	139.77[a]	181.94[a]	194.39[a]
275 kg N ha^{-1}	78.10[a]	143.14[a]	187.16[a]	201.30[a]
Average	75.64	133.12	171.60	186.12
Interaction	(-)	(-)	(-)	(-)

[a, b] Numbers followed by the same letter indicate no significant different at the 5% level; (-): no interaction

3.5. Relationship of growth parameters with plant dry weight

Vegetative growth of plants will affect the production of plant dry weight. The results of the correlation analysis between number of leaves, leaf length, leaf width, angle of leaves and plant height to plant dry weight were shown in Table 6.

Plant height was positively correlated (0.81) with plant dry weight. It means that increasing plant height will affect the increasing number of the plant dry weight. In other parameters, the number of leaves, stem diameter, leaf length, and leaf width also have a positive correlation with the plant dry weight, so that increasing number of these parameters will also increase plant dry weight. The leaf angle did not correlate with plant dry weight, thus, the increase or decrease on leaf angle did not affect the production of plant dry weight.

Tabel 6. Correlation analysis between number of leaves, leaf length, leaf width, angle of leaf and plant height on *plant dry weight*

	PH	*NL*	*SD*	*AL*	*LL*	*LW*	*DW*
PH	1.00						
NL	0.76**	1.00					
SD	0.86**	0.81**	1.00				
AL	0.17 ns	0.17 ns	0.14 ns	1.00			
LL	0.89**	0.73**	0.88**	0.08 ns	1.00		
LW	0.80**	0.71**	0.87**	0.30*	0.84**	1.00	
DW	0.81**	0.68**	0.76**	0.10 ns	0.79**	0.73**	1.00

** = very significant; * = significant; ns = non-significant; PH = plant height; NL = number of leaves; SD = stem diameter; AL = angle of leaves; LL = leaf lenght; LW = leaf width; DW = *plant dry weight*

4. Conclusions

Based on the results of the research obtained, some conclusions can be drawn as follows: (a) There were no interaction between cultivars, weed and nitrogen dose on plant height, leaf number, leaf length, leaf width, leaf angle, and stem diameter. There were no differences in stem diameter and plant height in Bisi 18, NK 33, DK 95 and Sukmaraga cultivar. Bisi 18 and DK 95 cultivar produced the most leaves number; (b) Weed suppressed the leaf number, stem diameter, leaf length, leaf width, leaf angle and plant height so that plant growth was higher in weed-free condition; (c) Nitrogen dose of 25 kg N ha^{-1} produced the shortest plants, the least leaves, and the smallest stem diameter.

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