Shoot Pruning and Potassium Application Effect on Cucumber (Cucumis Sativus L.) Seeds Production and Quality

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Abstract. In order to determine the effect of shoot pruning and potassium fertilization on the production and quality of cucumber (Cucumis sativus L) seeds, a factorial experiment based on randomized complete block design with three replications was carried out in Arjasa Village, Jember regency, East Java, Indonesia, in 2018. The first factor is shoot pruning which consists of 4 levels i.e. of 6th internode, 8th internode, 10th internode, and 12th internode shoot pruning. The second factor is the potassium fertilization in three levels i.e. 100 kg ha-1, 200 kg ha-1, 300 kg ha-1. Production and quality of seed cucumber was assessed based on fruit weight, number of grain per fruit, percentage of filled grain, 1000 grains weight, seed viability and vigor. The results indicated that was significant different on interactions of two factors effect on physiological ripe fruit weight, grain number and percentage of filled grain. The 8th internode pruning gives best result on physiological ripe fruit weight, seed viability and vigor. Application of potassium at a dose of 300 kg ha-1 gives the best results on fruit weight, 1000 grain weight and percentage of filled grain.

1. Introduction
Cucumber (Cucumis sativus L) is a vegetable plant of the family Cucurbitaceae which is consumed mainly in the form of fresh vegetables. In Indonesia, cucumber cultivation is carried out in the regions of West Java, East Java, Central Java and North Sumatra. However, the production of cucumber plants is still far from its potential yields, that is 30-35 tons per hectare [1]. Cucumber productivity in 2016 only reached 10.19 tons per hectare [2]. The main problem for farmers is the availability of quality seeds. The availability of quality seeds is determines the success of crop cultivation. High quality seeds are seeds that meet the stated quality standards with a minimum germination capacity of 86%, seed purity of 95%, maximum impurities of 2% are not deformed and the identity of the varieties is in accordance with their cultivars [3]. The quality of cucumber seeds can be done throught improving the quality of fruit. Thus, increasing the quality and quantity of cucumber seeds can be done by increasing crop cultivation. Shoot pruning on cucumber plants can significantly increase crop production. Increased cucumber production through shoot pruning has been reported by several researchers including Ref. [4], [5], [6], and [7]. Other researchers report, shoot pruning can increase the growth and production of tomato plants [8], watermelon [9] and [10]. Pruning techniques will change the microenvironment and reduce the emergence of competition between the use of photosyntheate between the fruit and shoots.

Increasing the number of productive branches of plants due to bud pruning causes the fruit to form and the number of leaves more productive. Growth balance can be supported by fertilizing using nutrients that play an important role in the process of seed production, namely potassium. Potash & Phosphate Institute [11] states that potassium plays a role in controlling stomata activity by changing

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the concentration of fluid in guard cells that causes stomata to open and close to supply oxygen and carbon dioxide. In the process of photosynthesis, among others, is the activation of enzymes and also its involvement in the process of formation of ATP (Adenosine triphosphate). Potassium functions to balance the electric charge during the formation of ATP. Potassium fertilizer application can increase the percentage of filled grain and seed quality [12]. The combination of the two treatments is expected to increase the production and quality of cucumber seeds.

2. Materials and Method
In order to determine the effect of shoot pruning and potassium fertilization on the production and quality of cucumber (*Cucumis sativus* L) seeds was conducted on the land of Arjasa Village, Arjasa District, Jember Regency, East Java Province and the Seed Technology Laboratory of the Department of Agronomy, Faculty of Agriculture, University of Jember in 2018. The experiment was carried out on Latosol soil with a height of about 250 m above sea level. The results of soil analysis are shown in Table 1.

| No. | Properties | Amount     | Description |
|-----|------------|------------|-------------|
| 1.  | Nitrogen   | 0.11 %     | low         |
| 2.  | PO₄⁴⁻      | 23.43 ppm  | high        |
| 3.  | Potassium  | 0.20 Cmol/Kg | low        |
| 4.  | pH         | 6.32       | rather acid |

The factorial experiment 2x2 based on randomized block design, with the first factor is shoot pruning and the second factor is the dose of potassium fertilizer with three replications. The treatment of shoot pruning consisting of 4 levels, namely the 6th internode shoot pruning (6th ISP), 8th internode shoot pruning (8th ISP), 10th internode shoot pruning (10th ISP), and 12th internode shoot pruning (12th ISP). The second factor is dosage application consists of 3 levels, namely potassium fertilization with a dose of 100 kg/ha⁻¹ (P1), 200 kg/ha⁻¹ (P2), and 300 kg/ha⁻¹ (P3). Analysis of variance was carried out to examine the effect of variance on each experiment and its combination. Duncan's Multiple Range Test (DMRT) multiple distance test at 95 percent confidence level is carried out for further testing if the variance is significant and very real [13].

Planting and maintenance are carried out in accordance with the standard methods of cucumber plants cultivation. The shoot pruning and addition of potassium are adjusted to the treatment being tried. Increased cucumber seed production due to shoot pruning was assessed from fruit weight (physiologically ripened), number of seeds, weight of 1000 seeds and percentage of filled seeds produced. Meanwhile, seed quality was assessed for vigor and seed viability.

3. Result and Discussion
The shoot pruning has a big role in the effort to increase the production of cucumber plants both for consumption purposes and for the purpose of seed production. Pruning shoots can increase crop production through enhancing vegetative growth and the formation of productive branches [14]; [15]; [16]. Figure 1 shows the growth of productive branches due to shoot pruning in cucumbers.
In this experiment, increasing the production and quality of cucumber seeds was done through the treatment of shoot pruning and application of potassium fertilizer at various doses. There was a significant interaction between the two treatments on the ripe fruit weight, grain number and percentage of filled grain. Meanwhile, shoot pruning significantly affected the seed viability and vigour. The application of potassium fertilizer significantly affected the weight of fresh fruit (Table 2).

### Table 2. Analysis of variance for experimental traits as affected by shoot pruning stage and potassium levels

| SOV                        | df | Replication | Shoot Pruning (SP) | Potassium Levels (P) (SP) x (P) | Error | Ripe Fruit Weight (kg ha\(^{-1}\)) | Fruit number | Percentage of filled grain | 1000 grains weight (g) | Seed viability (%) | Seed Vigor (%) |
|---------------------------|----|-------------|--------------------|--------------------------------|-------|------------------------------------|--------------|--------------------------|---------------------|-------------------|-----------------|
| Replication               | 2  | 1.49 ns     | 194.77 ns          | 2.07 ns                       | 0.002 ns | 133.78 ns                          | 14751.21**   | 1828.36**                | 173.05              | 198.26            |                 |
| Shoot Pruning (SP)        | 3  | 387.93**    | 2532.14 ns         | 33.31 ns                      | 0.14 ns | 827.70*                            | 3261.11*     | 195.70 ns                | 463.56 ns           |                 |                 |
| Potassium Levels (P)      | 2  | 49.37 ns    | 14751.21**         | 1828.36**                     | 0.12 ns | 211.11 ns                          | 1062.31      | 12.84                    | 15.81               |                 |                 |
| (SP) x (P)                | 6  | 40.23*      | 3261.11*           | 55.71**                       | 0.03 ns | 195.70 ns                          | 120.20       | 4.23                     | 11.21               |                 |                 |
| CV (%)                    | 22 | 13.01       | 12.20              | 4.23                          | 11.21 | 15.81                              | 19.06        |                          |                     |                 |                 |

ns, * and ** are non-significant and significant at 5% and 1% probability level respectively.

3.1. The effects of shoot pruning and potassium fertilization on seed production

The cucumber seed production is assessed based on character physiological ripe fruit weight, grain numbers, and percentage of filled grain. In this experiment, the number of cucumber is limited to 3 for seed production. The results of pruning shoots in plants as shown in Figure 2.
To produce quality seeds, cucumbers are harvested during physiological ripening (Figure 3).

Test results of the effect of shoot pruning, potassium fertilization and their interactions on the physiological ripe fruit weights is shown in Tables 3.

Shoot pruning, potassium fertilizer and their interaction had significantly effect on physiological ripe fruit weight. Shoot pruning is an effort to balance vegetative growth. The highest physiological ripe fruit weight was obtained from 300 kg ha⁻¹ application dose and 12th internode shoot pruning treatment, that is 41.52 ton ha⁻¹. The combination of 100 kg ha⁻¹ application dose and 6th internode shoot pruning treatment got the lowest physiological ripe fruit weight (Figure, 4) Pruning that is done after the fruit is formed causes the assimilate translocation center to be shifted towards the fruit that is starting to form.
Table 3. Effect of Shoot Pruning, Potassium Level and Their Interaction on Physiological Ripe Fruit Weight (ton ha\(^{-1}\))

| Shoot Pruning                  | Potassium Level | Mean  |
|-------------------------------|-----------------|-------|
|                               | 100 kg ha\(^{-1}\) | 200 kg ha\(^{-1}\) | 300 kg ha\(^{-1}\) |       |
| 6\(^{th}\) internode shoot pruning (6\(^{th}\) ISP) | 19.67 c         | 23.04 b         | 18.87 d         | 20.53 |
| 8\(^{th}\) internode shoot pruning (8\(^{th}\) ISP) | 29.13 b         | 31.41 ab        | 29.33 c         | 29.96 |
| 10\(^{th}\) internode shoot pruning (10\(^{th}\) ISP) | 28.59bc         | 26.15b          | 36.67b          | 30.47 |
| 12\(^{th}\) internode shoot pruning (12\(^{th}\) ISP) | 33.30a          | 34.41 a         | 41.52 a         | 36.41 |
| Mean                          | 27.67           | 28.75           | 31.60           |       |

Means in the row (uppercase) and in the column (lowercase) with the same letter are not significantly different by Duncan’s Multiple Range Test (p=0.05).

Figure 4. The Effect of Shoot Pruning And Potassium Fertilization on Physiological Ripe Fruit Weight (Ton ha\(^{-1}\))

The results also indicate a significant interaction of shoot pruning and potassium fertilization on grain numbers and percentage of filled grain (Figure 5 and 6).
Figure 5. The Effect of Shoot Pruning and Potassium Fertilization on Grain Numbers

Figure 6. The Effect of Shoot Pruning and Potassium Fertilization on Percentage of Filled Grain

Shoot pruning and application of potassium showed significant interactions on the number of seeds per plant and percentage of filled grain. Pruning shoots at the 12th segment and application of potassium as much as 300 kg ha\(^{-1}\) produced 315.61 seeds (Figure 5) and 95.48\% filled grain (Figure 6).

3.2. The effects of shoot pruning and potassium level on production and seed quality
Increasing the production of cucumber seeds must be followed by developments in the quality of seeds so that efforts to increase cucumber production can be achieved. Seed quality standards are usually determined by the germination and growing strength of the seeds. Seed quality is tested based on the value of seed viability and seed vigor. Quality seeds will grow normally. Figure 7 shows the seeds that grow normally and abnormally.
Figure 7. Normal and abnormal seedling after viability and vigor testing
(Source: author's documentation)

Shoot pruning on cucumber plants significantly affected to seed viability and seed vigor. While the increase in potassium application had no significant effect on 1000 grains weight, seed viability and seed vigor (Table 4)

Table 4. Mean comparison for seed quality and quantity as affected by shoot pruning and potassium levels.

| Treatment                        | 1000 Grains Weight (g) | Seed viability (%) | Seed Vigor (%) |
|----------------------------------|------------------------|--------------------|----------------|
| Shoot pruning                    |                        |                    |                |
| 6th internode shoot pruning      | 21.2 a                 | 85.78 b            | 80.00 b        |
| 8th internode shoot pruning      | 23.4 a                 | 93.78 a            | 72.00 c        |
| 10th internode shoot pruning     | 23.1 a                 | 70.67 c            | 58.67 d        |
| 12th internode shoot pruning     | 22.7 a                 | 82.67 bc           | 84.89 a        |
| Potassium levels                 |                        |                    |                |
| 100 kg ha\textsuperscript{-1}    | 22.6 a                 | 79.33 a            | 66.67 a        |
| 200 kg ha\textsuperscript{-1}    | 21.6 a                 | 87.67 a            | 77.00 a        |
| 300 kg ha\textsuperscript{-1}    | 23.6 a                 | 82.67 a            | 78.00 a        |

Means in the column with the same letter are not significantly different by Duncan’s Multiple Range Test (p=0.05).

According to Ref. [17] quality cucumber seeds must have germinating power and strength growing by 86 percent. The results of germination and growth strength of cucumber seeds in this experiment are shown in Figure 8.
Figure 8. Effect of shoot pruning on Seed Viability and Vigor

The 8th ISP treatment has a percentage of germination of more than 86 percent which is the minimum limit in seed certification [17], which is 93.78 percent. Pruning of shoot on the 8th segment has more productive branches so that the filling of the seeds is optimal because there are more sources. According to Ref. [15] pruning is one of the cultivation techniques to increase seed production, namely by increasing the vegetative part of the plant so that the surface of photosynthesis increases and the production of carbohydrates increases. Pruning can provide an optimal microclimate in the process of plant metabolism. To get the above values, of course, must be balanced with optimal fertilization. Fertilization treatment does not show a significant difference in germination even though potassium fertilizer has an important role in the process of seed formation. This is because potassium fertilizer at all doses is sufficient for plants, while the efficiency of fertilizer use is influenced by shoot pruning. Optimal fertilization and a greater number of productive branches can produce quality seeds because more photosynthates are formed so that the filling of the seeds optimally.

Furthermore vigorous or growing strength is part of the seed quality standards. Vigorous or growing strengths represent the ability of seeds to survive on unfavourable land conditions representing uncertain conditions in the field. Based on the data above the top pruning treatment that has the best results on the growth strength variable is the 12th ISP, but the overall treatment has not met the minimum percentage of growth strength according to Ref. [17] which is 86 percent. The test results show that the shoot pruning treatment has not been able to improve seed quality optimally even though it has shown differences in each treatment. Pruning the 12th segment produces the highest value of 84.89 percent, showing that pruning the 12th segment can improve the efficiency of seed filling even though it is not enough to meet seed quality standards.

4. Conclusion
Pruning shoots at the 12th segment and giving 300 kg / ha of potassium can increase the weight of cucumbers, while the best seed production is produced by applying 200 kg / ha of potassium fertilizer. Pruning shoots at the right section and giving the optimal dose of potassium fertilizer can have a positive impact on the yield of cucumber seeds.

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