The effect of swimmer crab flour (*Protunus pelagicus*) and Arbuscular Mycorrhizal Fungi on flowering and yield of Japanese Cucumber (*Cucumis sativus* L.)

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**Abstract.** Swimmer crab flour (*Protunus pelagicus*) which has high Ca content and Arbuscular Mycorrhizal Fungi (AMF) can be used to overcome acid soil. The aim of this research was to know the interaction effect of swimmer crab flour and AMF on increasing acidic dry soil productivity for the growth and yield of Japanese cucumber plant. The polybag research was conducted at Nagreg Subdistrict, West Jawa, Indonesia from May to July 2018 using Randomized Block Design with two factors and three replications. The first factor was swimmer crab flour doses (control, r1 = 9 g 5 Kg soil\(^{-1}\), 12 g 5 kg soil\(^{-1}\), 15 g 5 kg soil\(^{-1}\) and 18 g 5 Kg soil\(^{-1}\)) and the second factor was AMF dosage (control, 5 g crop\(^{-1}\) and 10 g crop\(^{-1}\)). The results showed that there was an interaction effect of swimmer crab flour and AMF on the root infection degree, there was main effect of swimmer crab flour on flowering time, dry weight of fruits, and harvest index of cucumber, and there was an main effect of AMF on the harvest index. Thus the application of swimmer crab flour more reliable to increase japanese cucumber production.

1. **Introduction**

Indonesia has 191.1 million ha mainland and approximately 149.5 million ha or 78.2% of the soil is categorized as suboptimal, with the widest spread is acid dry soil [1]. The problem of acid dry soil for plant cultivation is related to high Al content which is fixed phosphate [2], low nutrient and organic matter content, also sensitivite to erosion.

The problem of acidity soil can be solved by application of swimmer crab flour and arbuscular mycorrhizal fungi (AMF). Swimmer crab flour has high calcium content that is important for pH increasing thus phosphate can be released from Al fixation. AMF with 30 meter soil\(^{-1}\) external hypha can increase Phosphate up take [3-5]. Phosphate is an element necessary for the process flowering and crop yield of Japanese cucumber.

In this study, phosphate supply is obtained via the mechanism of increasing pH resulting from application of swimmer crab flour and after more P soil available plants will absorb them through AMF external Hypha.

The aim of this research was to know the interaction effect of swimmer crab flour and AMF on increasing acid dry soil productivity for the growth and yield of Japanese cucumber crop.
2. Materials and method

The materials used were acid soil from Tasikmalaya West Java Province (S: 06°55, 937’ and East E: 107°43,084’) 557 m above sea level, mix AMF inoculum (Gigaspora, Glomus, Entropospora and Acaulospora) from Lampung province, Japanese cucumber (curry) seed var Roberto 92, sheep manure, Urea, TSP, KCl. A polybag-trial was carried out at Nagreg subdistrict, West Java, Indonesia (S=702’18, 13207”, E=107054’49,001”) 750 m above sea level from May to July 2018, using Randomized Block Design with two factors and three replications.

The first factor was swimmer crab flour dosage: 

- \( r_0 \) = control, equal to 0 t ha\(^{-1}\)
- \( r_1 \) = 9 g 5 Kg soil\(^{-1}\), equal to 3.6 t ha\(^{-1}\)
- \( r_2 \) = 12 g 5 kg soil\(^{-1}\), equal to 4.8 t ha\(^{-1}\)
- \( r_3 \) = 15 g 5 kg soil\(^{-1}\), equal to 6.0 t ha\(^{-1}\)
- \( r_4 \) = 18g 5 Kg soil\(^{-1}\), equal to 7.2 t ha\(^{-1}\)

The second factor was AMF dosage:

- \( f_0 \) = control
- \( f_1 \) = 5 g crop\(^{-1}\)
- \( f_2 \) = 10 g crop\(^{-1}\)

Parameters evaluated were root infection degree, flowering time, dry weight of fruits and harvest index were measured at harvest. The data analysis was performed using F test at 5 % level and continued with Duncan Multi Range Test at 5 % level.

Five kilos of acid soil was inserted into polybags. Swimmer crab flour dosage appropriate with the treatment and sheep manure were applied 2 weeks before seed planting. Two seeds were planted 5 cm deep in the polybag. AMF was inoculated in the same time 3 cm under seed. Crops were watered in the morning and the afternoon when there was no rain. Continued fertilization was given at 7 Days After Planting (DAP) and 21 DAP, spacing was done at 14 DAP, pruning old leaves at 20 DAP, pest and disease control was done by mechanical method and pesticide, and the last activity was harvest at 45 DAP.

3. Results and discussion

3.1. Root infection degree

There was interaction showed from application of swimmer crab flour and AMF on root infection degree. Increasing AMF dosage improved root infection degree within all swimmer crab flour dosage. The highest root infection degree was shown by a combination of treatment 10 g crop\(^{-1}\) of AMF and 7.2 t ha\(^{-1}\) of swimmer crab flour (Table 1).

AMF inoculation 10 g crop\(^{-1}\) plus swimmer crab flour 3.6 t ha\(^{-1}\) - 7.2 t ha\(^{-1}\) produced the highest of root infection degree. Root infection degree has close correlation with soil available phosphate [6]. In this study soil available P was very low which would enhance root infection and mix inoculum (Gigaspora, Glomus, Entropospora and Acaulospora) used was a factor that supports the success of infection. That AMF species and its density affect root infection [7].

The other factor was organic matter. In this trial the swimmer crab flour used contained high C-organic (13,54 %). As a carbon source, organic amendments exert a great influence on the heterotrophic microbial communities [8]. AMF colonization can be stimulated by organic management [6]. Highest root colonization with high organic matter treatment [9].

Table 1. The Effect of swimmer crab flour and AMF dosage on root infection degree.

| swimmer crab flour | AMF dosage              | root infection degree (%) |
|--------------------|-------------------------|--------------------------|
| r\(_0\) ( 0 t ha\(^{-1}\)) | f\(_0\) (0 g.crop\(^{-1}\)) | 00.00 a                  |
|                    | f\(_1\) (5 g.crop\(^{-1}\)) | 26.71 a                  |
|                    | f\(_2\) (10 g.crop\(^{-1}\)) | 19.06 a                  |

The data was statistically analyzed using F test at 5% level and continued with Duncan Multi Range Test at 5% level.
Table 1. Cont.

|      | 00.00 a | 32.12 b | 45.17 b |
|------|---------|---------|---------|
| r₁ (3.6 t ha⁻¹) | A       | B       | C       |
| r₂ (4.8 t ha⁻¹) | 00.00 a | 33.45 b | 45.46 b |
| r₃ (6.0 t ha⁻¹) | 00.00 a | 34.00 b | 45.57 b |
| r₄ (7.2 t ha⁻¹) | 00.00 a | 34.82 b | 50.02 b |

Remarks: Numbers followed by same small letter in vertical and capital letter in horizontal are not significantly different based on Duncan’s Multiple Range Test at 5% level.

3.2. Flowering time
Application of swimmer crab flour and AMF had no interaction effect on flowering time. Increasing dosage of swimmer crab flour accelerated flowering time, while AMF inoculation did not affect flowering time (Table 2).

Table 2. The Effect of swimmer crab flour and AMF dosage on flowering time.

| Flowering time average (DAP) |
|-----------------------------|
| swimmer crab flour           |
| r₀ (0 t ha⁻¹)               | 40.11 a |
| r₁ (3.6 t ha⁻¹)             | 36.89 b |
| r₂ (4.8 t ha⁻¹)             | 36.00 bc|
| r₃ (6.0 t ha⁻¹)             | 35.00 c |
| r₄ (7.2 t ha⁻¹)             | 35.56 bc|
| AMF                         |
| f₀ (0 g crop⁻¹)             | 36.93 a |
| f₁ (5 g crop⁻¹)             | 37.13 a |
| f₂ (10 g crop⁻¹)            | 36.06 a |

Remarks: Numbers followed by same small letter in vertical are not significantly different based on Duncan’s Multiple Range Test at 5% level.

Application of swimmer crab flour 3.6 t ha⁻¹ to 7.2 t ha⁻¹ accelerated the flowering time. The fastest flowering time of 35 days occurred on crops that were given swimmer crab flour 6.0 t ha⁻¹. The process of flowering was influenced by element of P. This element plays a role in the formation of carbohydrates and proteins to induce flowering [10]. P supply from swimmer crab flour and media was enough to support these process.

3.3. Harvest index
There was no interaction effect of swimmer crab flour and AMF on harvest index. Swimmer crab flour and AMF showed main effect on harvest index. Application of swimmer crab flour and AMF increased harvest index (Table 3).

Table 3. The Effect of swimmer crab flour and AMF dosage on Harvest Index.

| Harvest Indexes |
|-----------------|
| swimmer crab flour |
| r₀ (0 t ha⁻¹) | 0.23 a |
| r₁ (3.6 t ha⁻¹) | 0.38 b |
| r₂ (4.8 t ha⁻¹) | 0.39 b |
Table 3. Cont.

|        |       |       |
|--------|-------|-------|
|        | AMF dosage |       |
|        |            |       |
| r3 (6.0 t ha\(^{-1}\)) | 0.41 b |       |
| r4 (7.2 t ha\(^{-1}\)) | 0.43 b |       |
| AMF dosage |      |       |
| f0 (0 g crop\(^{-1}\)) | 0.32 a |       |
| f1 (5 g crop\(^{-1}\)) | 0.38 b |       |
| f2 (10 g crop\(^{-1}\)) | 0.39 b |       |

Remarks: Numbers followed by same small letter in vertical are not significantly different based on Duncan’s Multiple Range Test at 5% level.

Application of swimmer crab flour increased the harvest index of 65-86% compared to the control. This figure is greater than the increase caused by inoculation of the AMF that only 18.75%-21.86%. Harvest index associates with photosynthate partition. The element of P is involved in the photosynthate partition. The P element was met by the supply of swimmer crab flour and AMF which was able to absorb the low P available in the soil. Plant shoot and root biomass were improved by the addition of AMF [7].

3.4. Fruit fresh weight

The Effect of swimmer crab flour and AMF dosage on fruit fresh weight was only showed in main effect of swimmer crab flour. The addition dosage of swimmer crab flour increased fruit fresh weight significantly (Table 4).

Increasing in fruit fresh weight was very large with applying of swimmer crab flour due to the Ca and P contained in this flour. Calcium (Ca) element is required to support generative growth and P for the formation of flowers and fruit. In this trial increasing fruit fresh weight caused by swimmer crab flour. While mix inoculum AMF showed no effect on the fruit fresh weight as also related to the survival of the AMF [11]. AMF species differs adapted to soil pH. Acaulospora and Glomus are tolerant to acidity [12]. Thus not all species work in increasing P absorption.

Table 4. The Effect of swimmer crab flour and AMF dosage on fruit fresh weight.

| swinner crab flour | fruit fresh weight (g) |
|-------------------|------------------------|
| r0 (0 t ha\(^{-1}\)) | 23.32 a |
| r1 (3.6 t ha\(^{-1}\)) | 150.66 b |
| r2 (4.8 t ha\(^{-1}\)) | 222.11 c |
| r3 (6.0 t ha\(^{-1}\)) | 227.30 c |
| r4 (7.2 t ha\(^{-1}\)) | 240.22 c |
| AMF dosage        |           |
| f0 (0 g crop\(^{-1}\)) | 185.17 a |
| f1 (5 g crop\(^{-1}\)) | 152.09 a |
| f2 (10 g crop\(^{-1}\)) | 180.95 a |

Remarks: Numbers followed by same small letter in vertical are not significantly different based on Duncan’s Multiple Range Test at 5% level.

4. Conclusion

The application of swimmer crab flour accelerated flowering and increased harvest index and the weight of fresh fruit. While the AMF succeeded in increasing the harvest index. Thus the application of swimmer crab flour more reliable to increase Japanese cucumber production.

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