Vol. 6 No. 2 March 2023
ISSN : 2597 - 8713 (ONLINE)
ISSN : 2598 - 5167 (PRINT)
AGRICULTURAL SCIENCE
Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
Available on :
https://agriculturalscience.unmerbaya.ac.id/index.php/agriscience/index

Maximizing Growth and Yield of Garlic by using Different Sources and Dosages of Nitrogen and Chicken Manure on Andisol Soil

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Article History: Received: December 28, 2022; Accepted: February 20, 2023

ABSTRACT

Low soil fertility is a limiting factor for crop production in general. Increasing the yield of garlic with balanced fertilization is an important key identified, also the right type and dose of fertilization is also a major problem. The purpose of this study was to determine the effect of inorganic fertilizer (nitrogen) and chicken manure doses on the growth and yield of garlic. The experimental design used in this research was a completely randomized design. The first factor was chicken manure, which consists of two levels, i.e., without chicken manure and 40 t/ha of chicken manure. The second factor was the dosage of N fertilizer which consists of twenty levels, ie, no fertilizer, urea with a dose of 50, 100, 150, 200, 250, 300, 350, 400. 450, 500 kg/ha, ZA with a dose of 50, 100, 150, 200, 250, 300, 350, 400. 450, 500 kg/ha. The results showed that the combination of urea fertilizer 500 kg/ha and chicken manure 40 tons/ha gave the highest yield of stored dry tubers and was significantly higher than control plots and other treatment combinations. Likewise other growth and yield parameters increased progressively. Therefore, it can be concluded that to increase the yield of garlic in the study area, 500 kg/ha of urea fertilizer and 40 tons/ha of chicken manure are needed. The recommendation is that on Andisol soil for garlic cultivation, it is better to use a combination of 500 kg/ha urea and 40 t/ha chicken manure.

Keywords: Cloves, compost, fertilizer, garlic, tuber yield

1. INTRODUCTION

Garlic (*Allium sativum* L.) is the most important vegetable in the Alliaceae family. Among various Allium sp., garlic plant ranks second after shallot in the world (Shafeek *et al*., 2015). and beneficial for health (Yadav *et al*., 2017). Many people consider and appreciate garlic because of its many medicinal properties (Tamiru & Gedamu, 2019) such as being used for the treatment and control of various diseases such as hypertension, intestinal worms, germs, bacterial and fungal diseases, diabetes, cancer, ulcers, rheumatism etc. (Abdel-Razzak & El-Sharkawy, 2013).

For the successful commercial cultivation of garlic plants, many factors such as climate, soil, irrigation, fertilizer and nutrient management, spacing, growing season, etc. must be considered. Adewale *et al*., (2011) asserted that soil fertility is the main constraint that affects all aspects of crop production. Farmers generally use inadequate nutrient inputs, inappropriate quality and inefficient combinations of fertilizers, which in the end prove to be very expensive. The consequence of this trend is a very unbalanced soil nutrient composition which ultimately leads to a decrease in crop yield potential (Tonfack *et al*., 2009). Chintala *et al*., (2012) added that the application of balanced fertilizers especially N, P, and K is very important for vegetative growth

 DOI : https://doi.org/10.55173/agriscience.v6i2.104

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and to produce plants with the best quality and high yields, especially on continuously cultivated soil.

Nitrogen is one of the main essential nutrients that make a major contribution to plant production. Plant growth and yield are highly dependent on soil N supply and proper management (Adhikari *et al*., 2016). The rate, timing, and method of application of nitrogen (N) fertilizers are closely related to plant growth, development, and yield (Shrestha *et al*., 2018). Unbalanced and poorly monitored nitrogen applications limit yields and lead to large losses of reactive nitrogen to the environment. (Cassman *et al*., 2002). Nitrogen increases the rate of leaf initiation and elongation of garlic at the beginning of growth (Sitaula *et al*., 2020). This increases the growth and development of tubers (Buwalda & Freeman, 1987) (Sitaula *et al*., 2020)

The application of different organic and inorganic nitrogen sources was significant in plant height, number of leaves per plant, but not on fresh tubers, tuber dry weight and tuber diameter (Aj *et al*., 2020). However, it is somewhat different from Hassan (2015) who stated that the highest tuber weight, number of cloves per bulb, clove weight and fresh garlic bulb yield were produced by fertilizing plants with 100% inorganic nitrogen fertilizer than the recommended one.

The use of organic fertilizers as a nitrogen source has been widely reported by researchers. As Badal *et al*., (2019) stated that the use of 15 t/ha manure and 4 t/ha vermicompost resulted in the maximum number of leaves. The same result was achieved by (Suthar, 2009), (Damse *et al*., 2016). Meanwhile, chicken manure 20 tons/ha produced the highest and different garlic yields compared to lower doses or without chicken manure (Adewale *et al*., 2011).

The novelty of this research is that it is a comprehensive study combining the use of different nitrogen sources, namely urea and ZA along with their doses with chicken manure. This study was conducted to determine the effect of different nitrogen sources and their doses and the use of chicken manure on the growth and yield of garlic (*Allium sativum*). With this research, it can provide recommendations and suggestions to farmers to make an economical combination of inorganic fertilizers and organic fertilizers to increase garlic productivity.

2. RESEARCH METHODS

This research was carried out from July 2019 to Nopember 2019 at Pancot, Kalisoro, Tawangmangu, Karanganyar. The geographical position of the study area is between 110° 40” - 110° 70” east longitude and between7° 28” - 7° 46” south latitude with an altitude of 1200 m above sea level and andisol soil

Experiment design

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The experimental design used in this research was a completely randomized design (CRD) with three replications. The first factor was chicken manure, which consists of two levels, i.e., without chicken manure and 40 t/ha of chicken manure. The second factor was the dosage of N fertilizer which consists of twenty levels, ie, no fertilizer, urea with a dose of 50, 100, 150, 200, 250, 300, 350, 400. 450, 500 kg/ha, ZA with a dose of 50, 100, 150, 200, 250, 300, 350, 400. 450, 500 kg/ha.

Research procedures

Soil and rice husk mixed in a ratio of 1:1 were put into polybags of 10 kg/polybag and chicken manure 200 g/polybag. Planting garlic seeds that have germinated to a depth of 2-3 cm with the pointed tip facing up. Watering every 4 days with gembor. Fertilization according to treatment by perforating the side of the plant with a depth of 2 cm. Pest control is done mechanically. Harvesting at the age of 140 cm with the characteristics of the leaves starting to turn yellow and the tips of the leaves begin to dry.

Parameters observed The parameters observed were the number of leaves, dry weight of stover, number of cloves/tubers, weight of fresh bulbs and weight of dry bulbs stored

Statistical analysis

The data of observations were analyzed using analysis of variance (ANOVA) at 5% significant levels. The treatment means were compared using Duncan′s new multiple range test (DMRT) at 5% significant levels.

3. RESULT AND DISCUSSION

Analysis of variance (Table 1) showed that there was an interaction between inorganic fertilizer with organic fertilizer of chicken manure on number of leaves, dry weight of crown, number of cloves per bulb, fresh weight of bulb, and dry weight of stored bulb

Table 1. Analysis of variance all parameters

	Number of leaves	Dry weight of crown	Number of cloves per bulb	Fresh weight of bulb	dry weight of stored bulb
Chicken Manure (O)	4.74*	33.54**	279.96**	207.52**	150.31**
Nitrogen dosage (N)	6.59**	49.54**	63.16**	67.73**	71.82**
O X N	5.27 **	81.37**	89.11**	74.65**	59.66**
CV (%)	15.86	8.42	7.80	8.20	10.51

Number of leaves

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Based on Table 1, there is an interaction between chicken manure and the dose of nitrogen source on the number of leaves parameter. The highest number of leaves was achieved at the interaction of a dose of urea 500 kg/ha with no chicken manure, but it was not different from the dose of chicken manure 40 t/ha with the same dose of urea (Table 2). The least number of leaves was achieved in the control, namely without the use of inorganic fertilizers and without chicken manure. With the large number of leaves in the use of urea fertilizer, this indicates that the role of inorganic fertilizers, especially urea, dominates.

In the absence of chicken manure, the highest number of leaves was given 500 kg/ha of urea which was significantly different with 50 and 100 kg urea doses or without nitrogen fertilizer. Likewise with the application of chicken manure, the highest number of leaves was the application of urea and ZA with a dose of 500 kg/ha

Adewale *et al*. (2011), stated that the application of poultry manure affects the number of leaves which increases along with the increase in the amount of poultry manure given. Plants that received 20 t/ha of poultry manure had the highest number of leaves, while the control plants had the least number of leaves. This is in accordance with the findings of Boldt *et al*. (2011) that an increase in vegetative growth was obtained when manure was applied to plants.

Manure is a compound fertilizer, it contains complete nutrients, including nitrogen. Kakar *et al*. (2002) stated that N fertilization is necessary to ensure the success of vegetative growth of garlic. Similarly, Abadi (2015) also reported that application of N significantly increased leaf width compared to lower doses and application of N fertilizer was nil. The increase in leaf width with an increase in fertilizer content is directly proportional to the leaf area index. (Fikru & Fikreyohannes, 2018).

Table 2. Number of leaves the effect of inorganic fertilizer (nitrogen) and chicken manure

Anorganic fertilizer (kg/ha)	Organic fertilizer of chicken manure	
	No organic fertilizer	Dosage 40 t/ha
No nitrogen	0.00 h	7.66 fg
Urea 50	7.33 g	8.66 c-g
Urea 100	8.667 c-d	10.00 a-g
Urea 150	10.667 a-g	12.66 ab
Urea 200	13.000 ab	12.66 ab
Urea 250	10.667 a-g	12.00 a-c
Urea 300	12.667 ab	11.66 a-d
Urea 350	10.667 a-g	10.66 a-g
Urea 400.	12.333 ab	12.66 ab
Urea 450.	12.667 ab	12.33 ab
Urea 500.	13.333 a	12.33ab

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ZA 50	12.000 a-c	8.33 d-g
ZA 100	8.000 e-g	11.33 a-e
ZA 150	11.667 a-d	11.33 a-e
ZA 200	11.000 a-f	11.33 a-e
ZA 250	11.667 a-d	11.33 a-e
ZA 300	9.667 b-g	11.33 a-e
ZA 350	10.667 a-g	11.00 a-f
ZA 400	11.333 a-e	12.33 ab
ZA 450	10.333 a-g	12.00 a-c
ZA 500	12.000 a-c	12.33 ab

Dry weight of crown

The highest dry weight of stover was at the interaction of 500 kg/ha urea fertilization with 40 t/ha chicken manure and it was different from the control and in all other combinations except for the interaction of 450 kg/ha urea dose with 40 t/ha chicken manure. The lowest dry weight of the stover was achieved in the control (Table 3). The interaction between urea fertilizer at a dose of 500 kg/ha and chicken manure at a dose of 40 kg/ha achieved the highest yield, this is because in addition to the effect of dose, urea has a N content of 46% while the ZA type of fertilizer contains only 21% N.

Plant growth and yield are highly dependent on soil N supply and proper management (Adhikari et al., 2016). The dose, timing, and method of nitrogen (N) fertilization are closely related to plant growth, development, and yield (Shrestha *et al*., 2018). Woldetsadik *et al*., (2015) also reported that the growth parameters increased significantly with nitrogen fertilization. The role of nitrogen in the synthesis of plant proteins, chlorophyll and enzymes (N), many researchers arrived at similar results (Ojo *et al*., 2014) and (Shafeek *et al*., 2015). Shafeek *et al*. (2015) in his research on two growing seasons concluded that garlic plants fertilized with organic nitrogen fertilizers reflected the highest percentage values of nitrogen, protein, phosphorus and potassium.

Fikru & Fikreyohannes, (2018) showed that the higher the N content, the dry weight per plant increased until it reached the highest N content. Kakar *et al*. (2002) reported that N accounted for a higher percentage of plant dry weight variation when increased from 50 to 200 kg/ha. Balanced fertilizer application is essential for vegetative growth and, thus, for producing the best quality and high yielding crops especially on continuously cultivated soils (Chintala *et al*., 2012)

Table 3. Dry weight of plant (g) the effect of inorganic fertilizer (nitrogen) and chicken manure

Anorganic fertilizer (kg/ha)	Organic fertilizer of chicken manure	
	No organic fertilizer	Dosage 40 t/ha
No nitrogen	0.00 o	8.67 ijk
Urea 50	5.00 n	10.00 hi
Urea 100	5.33 n	12.00 gh

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Urea 150	6.33 lmn	12.00 gh
Urea 200	8.67 ijk	13.33 fg
Urea 250	12.00 gh	15.33 e
Urea 300	15.00 ef	16.00 de
Urea 350	16.67 de	19.00 bc
Urea 400	19.00 bc	19.67 b
Urea 450	19.33 b	22.33 a
Urea 500	20.00 b	24.00 a
ZA 50	5.33 n	5.67 mn
ZA 100	6.67 lmn	6.67 lmn
ZA 150	8.00 jkl	7.33 klm
ZA 200	10.00 hi	7.67 kl
Anorganic fertilizer (kg/ha)	Organic fertilizer of chicken manure	
	No organic fertilizer	Dosage 40 t/ha
ZA 250	10.00 hi	7.67 jkl
ZA 300	12.00 gh	11.67 gh
ZA 350	15.00 ef	13.33 fg
ZA 400	16.67 de	15.33 e
ZA 450	16.33 de	17.33 cd
ZA 500	19.00 bc	19.67 b

Number of cloves per bulb

In observing the number of cloves/tubers there was a significant response due to the application of inorganic fertilizer (nitrogen) with organic fertilizer (chicken manure) (Table 4). The application of a combination of inorganic fertilizer (nitrogen) and organic fertilizer (chicken manure) significantly increased the number of cloves per tuber compared to no organic fertilizer application. The highest number of cloves per tuber was achieved in a combination of 500 kg/ha of urea fertilizer and 40 tons/ha of chicken manure, and the lowest was in the control.

The supply of nitrogen to plants increases the metabolic rate at which more carbohydrates are synthesized. This in turn increased tuber weight and total yield as confirmed by Assefa *et al*. (2015) who reported that 100 kg N/ha yielded maximum yields. In contrast, minimum yields were recorded in control plots; which could be due to the low fertility status of the native soil indicating the need for balanced fertilization A possible justification for this higher yield could be due to the combined effect of nitrogen's contribution to chlorophyll, enzyme and protein synthesis; because phosphorus is very important for root growth, phospho-protein and phospho-lipid. It may also be due to an adequate supply of nutrients that support tuber enlargement and weight (Assefa *et al.*, 2015).

The high number of cloves in the use of poultry manure can also be due to the fact that organic fertilizers improve the physical and chemical properties of the soil (Yahaya *et al*., 2010). The same thing was also reported by Adewale *et al*. (2011) and (Zakari *et al*., 2014). Sevak *et al*.

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(2012) have also reported the highest number of cloves per bulb of garlic administered with the recommended dose of nitrogen entirely through poultry manure (Sari et al., 2020) . Plants that received 20 t/ha of poultry manure had the highest average number of cloves per tuber at 5.7, followed by plants that received 15 t/ha of manure with an average of 5.3 cloves per bulb. The ability of poultry manure to improve the performance of garlic can also be attributed to the fact that organic fertilizers improve the physical and chemical properties of the soil (Yahaya *et al*., 2010).

Table 4. Number of cloves per bulb the effect of inorganic fertilizers (nitrogen) and chicken manure

Anorganic fertilizer (kg/ha)	Organic fertilizer of chicken manure	
	No organic fertilizer	Dosage 40 t/ha
No nitrogen	0.00 t	5.67 nop
Urea 50	3.33 s	7.33 kl
Urea 100	3.67 rs	8.33 ijk
Urea 150	3.67 rs	9.33 ghi
Urea 200	5.67 nop	10.33 fg
Urea 250	7.33 kl	12.00 cd
Urea 300	9.67 f-h	12.67 b-d
Urea 350	10.67 ef	13.33 b
Urea 400	12.67 de	13.67 b
Urea 450	12.67 b-d	15.00 a
Urea 500	13.00 bc	15.33 a
ZA 50	4.33 qrs	5.00 pq
ZA 100	4.33 qrs	6.67 lmn
ZA 150	4.67 pqr	6.67 lmn
ZA 200	5.67 nop	7.33 kl
ZA 250	6.00 mno	7.67 jkl
ZA 300	6.00 mno	7.67 jkl
ZA 350	6.00 mno	8.33 ijk
ZA 400	7.00 lm	8.67 hij
ZA 450	7.67 jkl	9.67 f-h
ZA 500	8.33 ijk	10.67 ef

Fresh weight of bulb

The interaction of inorganic fertilizer (nitrogen) with chicken manure was significantly different on the weight of fresh tubers (Table 5). The interaction between urea 500 kg/ha and chicken manure 40 t/ha showed the highest fresh tuber weight and was significantly different from the control and other combinations of treatments, including the interaction of ZA fertilizer at a dose of 500 kg/ha with chicken manure 40 tons/ha. The least weight of fresh tubers was achieved by the control.

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This is in line with his research by Tadilla (2018) which states that the use of inorganic nitrogen fertilizers alone has increased the weight of tubers, especially when combined with the use of manure. The combination application of different amounts of nitrogen and manure increased the average tuber fresh weight compared to the treatment without the combination application, the optimal combination was 50 kg/ha N with 10 t/ha manure (Tadila & Nigusie, 2018). This could be due to the requirement of this garlic cultivar for nitrogen in the sum equivalent to 50 kg/ha N and nitrogen available in 10 or 20 t/ha manure.

This study is in line with Gashaw *et al*. (2017)) who reported that the interaction effect of 50% of the recommended N and P and 5 t/ha of compost had a significant effect on the weight of garlic bulbs. Similar findings were reported by Damse *et al*. (2016) and Sitaula *et al*. (2020). which reports on the key role of integrating organic fertilizers, inorganic fertilizers and biofertilizers in increasing crop yields. Similar results for clove weight per tuber (Sevak *et al*., 2012). In contrast to this study, Alemu-Degwale (2016) documented insignificant results by combining compost with nitrogen and phosphorus fertilizers.

Table 5. Fresh weight of bulb (g) effect of inorganic fertilizer (nitrogen) and chicken manure

Anorganic fertilizer (kg/ha)	Organic fertilizer of chicken manure	
	No organic fertilizer	Dosage 40 t/ha
No nitrogen	0.00 v	34.00 tu
Urea 50	28.33 u	36.67 s-u
Urea 100	40.00 st	55.00 o-q
Urea 150.	51.67 p-r	61.65 n-p
Urea 200.	66.67 l-n	75.00 i-k
Urea 250.	61.67 n-p	86/67 f-i
Urea 300.	63.33 no	91.67 ef
Urea 350.	76.67 i-k	111.67 c
Urea 400.	83.33 f-k	113.33 bc
Urea 450.	88.33 e-h	121.67 ab
Urea 500.	90.00 efg	130.00 a
ZA 50.	30.00 tu	32.00 tu
ZA 100.	36.67 s-u	45.00 rs
ZA 150.	35.00 s-u	58.33 n-q
ZA 200.	50.00 qr	61.67 n-p
ZA 250.	60.00 n-q	78.33 h-k
ZA 300.	58.33 n-q	80.00 g-k
ZA 350.	65.00 m-o	85.00 f-j
ZA 400.	73.33 k-m	81.67 f-k
ZA 450.	85.00 f-j	96.67 de
ZA 500.	83.33 f-k	105.00 cd

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Dry weight of stored bulb

The highest dry weight stored tuber in the application of chicken manure 40 t/ha combined with urea 500 kg/ha and significantly different from the combination of urea 500 kg/ha without chicken manure. The lowest dry weight of stored bulb was achieved in the control. The role of the combination of nitrogen fertilizer (inorganic) with chicken manure is very important to increase the dry weight of stored tubers. Wahyudi et al., (2014) which stated that the application of chicken manure 30 t/ha and 80 kg/ha N, 20 kg/ha P_2O_5, 65 kg/ha K_2O gave the fresh weight of bulb, dry weight of bulb, number of cloves per bulb, and tuber diameter were the highest compared to other treatments.

Many studies link the role of organic fertilizers in increasing the dry tuber weight storage. Adewale et al. (2011) stated that there was an increase in tuber diameter, tuber weight and yield with an increase in the amount of poultry manure. This is in line with Zakari et al. (2014) who reported a significant increase. in growth and yield with organic fertilizers. The highest yield of 14.3 t/ha was recorded in plants receiving poultry manure at 20 t/ha. This is presumably because the nutrients N, Zn, Fe, Mn are supplied from poultry manure. Availability of Nitrogen and Phosphorus is very important for plant growth because it is the main and indispensable source of protein molecules and nucleic acids. It is also an integral part of the chlorophyll molecule, which is responsible for photosynthesis (Assefa et al., 2015).

Many references support the role of nitrogen in yields. Hassan (2015) explained that the increase in plant growth that contributes to tuber dry weight by increasing N levels may be due to its role in photosynthesis, protein synthesis, cell division and enlargement which are the basic steps of plant growth. In addition, N plays an important role in enzyme activity which reflects more of the product required for plant growth. Alemu-Degwale, (2016) also found that tuber dry matter increased by 14.21% due to an increase in N content from 0 to 46 kg/ha. Increasing N application from nil to 130 kg N/ha, tuber dry weight increased by 12.06%.

According to Choudhary et al. (2013) successive fertilization rates significantly increased tuber weight, number of cloves per tuber and tuber yield. Fikru & Fikreyohannes, (2018) reported that the maximum tuber yield (13.86 t/ha) was obtained by applying 100% fertilizer at the recommended dose, which was 41.7% higher than the control. Fikru & Fikreyohannes (2018) also reported that increasing N levels from 0 to 100 kg N/ha resulted in a progressive increase in the total yield of shallot bulbs.

Table 6. Dry weight of bulb (g) effect of inorganic fertilizers (nitrogen) and chicken manure

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Anorganic fertilizer (kg/ha)	Organic fertilizer of chicken manure	
	No organic fertilizer	Dosage 40 t/ha
No nitrogen	0.00 s	20.67 qr
Urea 50	18.33 r	26.67 qr
Urea 100	26.67 qr	36.67 op
Urea 150.	38.33 h-p	43.33 l-o
Urea 200.	46.67 k-o	55.00 i-k
Urea 250.	46.67 k-o	65.00 gh
Urea 300.	46.67 k-o	68.33 gh
Urea 350.	58.33 h-j	86.67 b-d
Urea 400.	66.67 gh	90.00 bc
Urea 450.	71.67 fg	93.33 b
Urea 500.	81.67 c-e	113.33 a
ZA 50.	18.33 r	18.67 r
ZA 100.	25.00 qr	30.00 pg
ZA 150.	23.33 gr	40.00 m-o
ZA 200.	38.33 h-p	48.33 k-n
ZA 250.	41.67 m-o	53.33 i-l
ZA 300.	41.67 m-o	60.00 hi
Anorganic fertilizer (kg/ha)	Organic fertilizer of chicken manure	
	No organic fertilizer	Dosage 40 t/ha
ZA 350.	48.33 k-n	61.67 hi
ZA 400.	50.00 j-m	58.33 h-j
ZA 450.	68.33 gh	73.33 e-g
ZA 500.	65.00 gh	80.00 d-f

4. CONCLUSION

Based on the results and discussion it can be concluded that. Giving chicken manure without giving inorganic fertilizer (nitrogen) can increase the number of leaves, dry weight of crown, number of cloves per bulb, fresh weight of bulb and dry weight of bulb of garlic. The highest dry weight of crown, number of cloves per bulb, fresh weight of bulb and dry weight of bulb of garlic was achieved by interaction of 500 kg/ha urea with 40 tons/ha of chicken manure.

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DOI : https://doi.org/10.55173/agriscience.v6i2.104

ISSN : 2597 - 8713 (ONLINE)
ISSN : 2598 - 5167 (PRINT)
Agricultural Science
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Agricultural Science
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Journal Of Agricultural Science And Agriculture Engineering
Faculty of Agriculture, Merdeka University Surabaya,Indonesia
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