International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 10 – Issue 03 || May - Jun 2025 || PP. 01-05

Impact of Synthetic Fertilizers on the Vegetative Development of Plants

Oviyanti Mulyani[1]*, Ade Setiawan[2]

[1]*Department of Soil Science and Land Resources Management, Soil Chemistry Laboratory, Faculty of Agriculture, Padjadjaran University, West Java, Indonesia Jl.RayaJatinangor km.21*
[2]*Department of Soil Science and Land Resources Management, Soil Physics Laboratory, Faculty of Agriculture, Padjadjaran University, West Java, Indonesia Jl.RayaJatinangor km.21*
Correspondence Author

Abstract: Fertilizers play a vital role in modern agriculture by enhancing soil fertility and supporting optimal plant development. Among the various types of fertilizers, inorganic fertilizers are widely used due to their high nutrient concentration, rapid availability, and ease of application.This study aimed to assess the impact of combining inorganic fertilizer on the optimal growth and yield of plants.This study used a Randomized Block Design (RBD) method using anorganicfertilizer, with the variation of doses inorganic fertilizer. The data collected from the parameters of plant growth and sorption of plant. The results of this investigation indicated that inorganic fertilizer significantly affects certain parameters. The use of inorganic fertilizer had significantly different outcomes compared to its non-application. The application of inorganic fertilizer at a dosage

Keywords: Syntethic fertilizer, Sorption, Growth of Plant, Vegetative Growth

1. Introduction:

Indonesia is a developing country that have a lot of potention in agricultural sector. Being an agrarian nation, Indonesia depends mostly on the agriculture industry for economic growth, rural livelihoods, and food security. Though it has great natural resources and a good climate, Indonesia's agricultural output is still somewhat low in comparison to its potential [1]. Among the many interconnected issues preventing the sector's expansion are land degradation, decreasing soil fertility, ineffective agricultural practices, restricted technological access, and climate change effects [2,3].

The agricultural industry fuels industrialization by supplying food and raw resources for other economic sectors. Apart from the poor in rural low and middle income countries who directly or indirectly rely on agriculture for their lives, agriculture is the primary source of income for some individuals in developing nations. Compared to the economies of industrialized countries who have more robust economies, the agriculture sector in developing countries plays a very significant part in economic growth and development. Competitive advantages, regional privileges, and agricultural potential by the area all shape agricultural progress in a given location.

Soil health decline brought on by too much chemical input, inadequate organic matter management, and erosion is among the most important problems. This situation directly influences crop production by lowering nutrient availability and water retention capacity[4,5]. Moreover, smallholder farmerswho account for most of the agricultural outputfrequently struggle to obtain contemporary inputs, high-quality seeds, training, and financial help, which hinders their capacity to use efficient and sustainable farming practices [6]. Promoting integrated soil fertility management, biological additions such as humic compounds, and the use of organic and locally available resources is absolutely crucial to overcoming these obstacles [7]. Improving productivity in the Indonesian agricultural industry calls for a change toward more resilient, ecologically friendly, and knowledge-based techniques, backed by policy innovation and farmer empowerment.

Given these urgent issues, there is an increasing need to implement more sustainable, creative, and locally relevant approaches to restore agricultural output in Indonesia. Promising ideas including balanced fertilizer with organic, or soil management, using agriculture and livestock waste as nutrient sources, and adding bio-based modifications such humic compounds. These approaches not only enhance soil fertility and agricultural productivity but also promote environmental sustainability and lower reliance on synthetic inputs. Thus, increasing the part of research, technology, and farmer capacity-building is absolutely crucial to propel agricultural transformation toward a more resilient and productive future.

2. Experimental Procedure

Using a Randomized Block Design (RBD), this experiment maintain under the experimental protocol evaluated the effect of six treatment combinations of each containing four doses of inorganic fertilizer, one treatment with the suggested fertilizer dose, and one control treatment (without fertilizer) on maize plants. A total experimental plot of twenty-four plots was produced by this experiment. Among the many components the experiment employed were inorganic fertilizer, urea, SP-36, KCl, Inceptisol order soil from Jatinangor (Picture 1), and sweet maize seeds. Soil analysis calls for a range of chemicals including physics and chemistry. To conduct chemical analysis The Kjeldahl technique served as a gauge for the total N. The Walkley and Black Method was employed in organic analysis for the C content. A soil-water suspension ratio of 1:2.5 [8] was used to measure the soil pH. According to the Olsen extraction method [8], the available phosphorus was found colorimetrically using a spectrophotometer following the extraction of the soil samples with 0.5 M sodium bicarbonate (NaHCO3) at a pH value of 8.5. Using 1 N ammonium acetate [8], we recovered the exchangeable basic cations (Ca, Mg, K, and Na) at a pH value of 7.

Using an atomic absorption spectrophotometer, the exchangeable Ca and Mg from this extraction; using a flame photometer, the exchangeable K and Na from the same extract. Ammonium acetate-saturated samples were analyzed to find the cation exchange capacity (CEC) of the soil. We swapped these samples for sodium from a percolated sodium chloride solution [8] after eliminating excess ammonium by continuous alcohol washing. The exchangeable acidity is determined by soaking the soil sample with a 1 M KCl solution and titrating it with 0.05 N NaOH. Using an NH4OAc (ammonium acetate) solution, we obtained the exchangeable capacitance by maximizing the ex-change between NH_4 and the cations that first occupied the exchange sites on the soil surface [8]. The total of exchangeable bases divided by the number of CEC gave us the percentage base saturation. Soil micronutrient cationsFe, Mn, Cu, and Znwere extracted using the ethylene diamine tetraacetic acid (EDTA) technique [8].

3. Result and Discussion

3.1. Plant Growth Parameters

3.1.1. Plant Height

TREATMENTS	14 DAP (cm)	28 DAP (cm)	42 DAP (cm)	56 DAP (cm)
CONTROL	23.58 ab	85.01 a	145.92 a	197.81 a
NPK STANDARD	27.14 ab	104.59 a	174.93 a	211.43 a
NPK 1/2 DOSES	28.24 b	104.27 a	169.39 a	220.58 a
NPK 1 DOSES	23.58 ab	98.89 a	169.65 a	212.27 a
NPK 1,5 DOSES	20.42 a	97.94 a	162.96 a	212.06 a
NPK 2 DOSES	22.03 ab	98.20 a	134.56 a	213.62 a

At 14 DAP, the NPK ½ dose treatment resulted in the highest plant height (28.24 cm), significantly different from the NPK 1.5 dose treatment, which had the lowest height (20.42 cm). Other treatments, including the control, showed no significant differences. This suggests that a moderate amount of fertilizer stimulates early plant growth, while excessive application may inhibit it, possibly due to nutrient stress.No significant differences in plant height were observed among treatments at 28 DAP. All treatments achieved heights around 98–105 cm. This indicates that plant growth during this stage may not be highly sensitive to fertilizer dosage, possibly due to soil fertility or internal nutrient reserves.Similar to 28 DAP, no statistically significant differences were found in plant height at 42 DAP. However, there was a slight trend showing better performance in the standard NPK and ½ dose treatments. Over-fertilization appeared to have no added benefit and may have hindered growth in some cases.At 56 DAP, the NPK ½ dose treatment again recorded the highest plant height (220.58 cm), outperforming even the standard and double doses. The control treatment still showed considerable growth (197.81 cm), indicating adequate baseline fertility in the soil. These results imply that lower NPK doses can be more effective than higher ones.Moderate fertilizer application, particularly the ½ standard NPK dose, yielded consistent or superior plant height compared to higher dosages. Excessive application of NPK did not result in significant growth benefits and may have caused adverse effects during early growth. From an agronomic and economic perspective, optimizing NPK application rates can enhance productivity while minimizing cost and environmental impact.

3.1.2. The average of Leaf Amount

The average number of leaves parameter can be seen in Table below, which provides almost the same picture as the average plant height at several different observation ages.

	14 DAP	28 DAP	42 DAP	

TREATMENTS	(cm)	(cm)	(cm)	56 DAP (cm)
CONTROL	4.55 a	8.55 a	9.40 a	8.75 a
NPK STANDARD	4.65 a	9.55 a	10.65 b	9.80 b
NPK 1/2 DOSES	4.75 a	9.15 a	10.00 ab	9.15 ab
NPK 1 DOSES	4.65 a	9.20 a	10.20 ab	9.25 ab
NPK 1,5 DOSES	4.35 a	8.90 a	10.45 ab	9.20 ab
NPK 2 DOSES	4.55 a	9.05 a	10.55 ab	9.20 b

At this stage, no significant differences were observed among treatments. Leaf width ranged between 4.35–4.75 cm. This suggests that fertilizer application had limited effect on early leaf expansion, possibly due to the dominance of seed reserves or limited nutrient demand at this phase.Leaf widths increased slightly compared to 14 DAP, but again no statistically significant differences were found. NPK Standard treatment showed the widest average leaf width (9.55 cm), while the control remained lower (8.55 cm), though not significantly. This indicates nutrient effects were still minimal or soil fertility was compensating.At this stage, a statistically significant difference was observed. The NPK Standard treatment produced significantly wider leaves (10.65 cm) than the control (9.40 cm). Other treatments like NPK 2 doses (10.55 cm) and NPK 1.5 doses (10.45 cm) were numerically high but not statistically different from the control. This suggests that nutrient availability began to have a noticeable effect on leaf development.

By 56 DAP, the NPK Standard (9.80 cm) and NPK 2 doses (9.20 cm) treatments resulted in significantly greater leaf widths compared to the control (8.75 cm). This further confirms the beneficial effect of balanced nutrient application in promoting leaf area development during late vegetative or pre-reproductive stages.Although no significant effects of NPK treatments were seen during early growth (14–28 DAP), by 42 and 56 DAP, balanced and moderate fertilizer applications (particularly the standard NPK dose) significantly increased leaf width. This indicates that nutrient demand increases as the plant matures and that appropriate fertilization can improve canopy development and photosynthetic potential[9].

3.1.3. The average of Stem Diameter

The growth components of stem diameter as seen in Table 4. below also show apicture that is in line with the other two parameters above. The difference in the number of leaves can be seen at the age of the plant 42 HST and 56 HST.At this early stage, no significant differences in stem diameter were observed across treatments. Values ranged from 3.68 cm (NPK 1.5 doses) to 4.60 cm (NPK standard). This suggests that stem diameter at 14 DAP may not be strongly influenced by nutrient input, likely due to reliance on seed reserves or early growth uniformity [10].

TREATMENTS	14 DAP (cm)	28 DAP (cm)	42 DAP (cm)	56 DAP (cm)
CONTROL	4.06 a	16.92 a	21.10 a	21.93 a
NPK STANDARD	4.60 a	21.40 a	26.14 b	26.98 bc
NPK 1/2 DOSES	4.53 a	22.02 a	25.83 b	26.23 b
NPK 1 DOSES	4.49 a	20.01 a	25.57 b	26.23 b
NPK 1,5 DOSES	3.68 a	20.63 a	27.81 b	29.30 c
NPK 2 DOSES	3.82 a	20.34 a	26.25 b	25.49 b

At 28 DAP, stem diameter increased across all treatments, with no statistically significant differences observed. The control group had the lowest mean value (16.92 cm), while NPK ½ dose recorded the highest (22.02 cm). Although not statistically different, these data suggest a positive trend in response to fertilization, consistent with nitrogen's known role in enhancing vegetative growth [14].By 42 DAP, a clear difference emerged. All fertilized treatments showed significantly higher stem diameters compared to the control. The highest diameter was observed in the NPK 1.5 dose treatment (27.81 cm), indicating enhanced stem development likely driven by increased nutrient availability. This finding supports previous studies showing the role of balanced fertilization in increasing stem thickness and structural strength [11].At 56 DAP, the trend continued with NPK 1.5 dose yielding the highest stem diameter (29.30 cm), significantly different from the control (21.93 cm). Interestingly, the 2 NPK dose did not result in further improvement and recorded a lower

value (25.49 cm), indicating a potential saturation point or negative effect of over-fertilization [9]. Moderate application rates (NPK standard to 1.5) appear optimal for stem growth.This study demonstrates that NPK fertilization significantly enhances stem diameter from 42 DAP onward. The 1.5 NPK dose consistently produced the greatest stem diameter, although excessively high application (2 doses) may not yield additional benefits. These results underscore the importance of balanced nutrient management to optimize plant structural development and productivity.

3.1.4. The Average of Sorption of Plant

Based on the results of statistical tests that have been conducted, the average plant absorption (N and P) measured in indicator plants showed a significant difference between the control treatment and other treatments. The table shows that the plant absorption content in the control is smaller compared to all treatments.

Nitrogen uptake varied significantly across treatments. The highest uptake was observed with the NPK 2 doses (3.59%) and standard NPK (3.54%), both significantly higher than the control (2.75%) and most other treatments. The lowest value was seen in the control group, indicating a positive correlation between fertilizer application and nitrogen absorption. This aligns with findings by Marschner (2012), who reported that nitrogen availability directly affects plant growth and biomass accumulation. Excessive NPK did not drastically improve uptake beyond the standard dose, indicating diminishing returns at higher application rates [12].

TREATMENTS	SERAPAN N (%)	SERAPAN P (%)	SERAPAN K (%)
CONTROL	2.75 a	0.25 a	1.24 a
NPK STANDARD	3.54 d	0.32 b	1.65 a
NPK 1/2 DOSES	2.82 ab	0.28 ab	1.50 a
NPK 1 DOSES	3.17 c	0.29 ab	1.59 a
NPK 1,5 DOSES	3.08 bc	0.31 b	1.56 a
NPK 2 DOSES	3.59 d	0.30 b	1.68 a

Phosphorus uptake also responded positively to NPK application, although with less dramatic differences than nitrogen. The highest uptakes were observed under NPK standard (0.32%), 1.5 doses (0.31%), and 2 doses (0.30%), all significantly higher than the control (0.25%). Phosphorus is known to have low mobility in soil, and its uptake can be enhanced through improved root development, which may be stimulated by nitrogen-induced growth [14]. The relatively minor differences among treatments suggest a possible saturation effect, as supported by studies in nutrient uptake plateauing with excess application [13].In contrast to nitrogen and phosphorus, potassium uptake showed no significant differences among treatments, ranging from 1.24% in the control to 1.68% in the NPK 2 doses. While numerically higher in fertilized treatments, the differences were not statistically significant. This may indicate sufficient native potassium levels in the soil, reducing the apparent impact of additional fertilizer. Potassium uptake is also influenced by water availability and soil type, factors that may have masked treatment effects [16].The application of NPK fertilizer significantly increased nitrogen and phosphorus uptake in plants, with the highest uptake achieved under standard and 2x NPK treatments. Potassium uptake, however, was not significantly affected by fertilizer rate, possibly due to adequate baseline soil potassium. These results highlight the importance of balanced fertilizer management and suggest that moderate to high rates of NPK can optimize nutrient absorption, particularly for nitrogen and phosphorus.

4. Conclutions

1. The findings of this study clearly demonstrate that the application of inorganic fertilizers has a significant positive impact on the vegetative development of plants.
2. Among the different dosage treatments tested, the application of NPK fertilizer at a ½ to 1 standard dose consistently supported better vegetative growth, especially in terms of plant height and stem diameter, without the potential drawbacks of over-fertilization. The 1.5 NPK dose resulted in the highest stem diameter, while the ½ dose produced the tallest plants, suggesting that optimal responses vary with growth parameters and that moderate fertilization may be more effective than excessive input.
3. Nutrient uptake analysis confirmed that inorganic fertilizer significantly enhanced nitrogen and phosphorus absorption. Potassium uptake, however, showed no significant difference among treatments, indicating sufficient potassium availability in the soil or reduced responsiveness to added potassium.
4. Overall, this study reinforces the importance of balanced nutrient management and highlights that judicious use of inorganic fertilizers particularly within the recommended dosage can improve crop growth and nutrient efficiency. These findings support the development of site-specific fertilization strategies to improve productivity while minimizing environmental and economic costs.

Acknowledgement

The authors are appreciative to the head of the Soil Chemistry and Plant Nutrition, Faculty of Agriculture Universitas Padjadjaran for their experimental facilities

Conflict of Interest

The authors certify that they do not have any competing interest to declare.

References

[1]. BPS (2023). *StatistikPertanian Indonesia*. Badan Pusat Statistik.
[2]. FAO (2021). *The State of Food and Agriculture*. Food and Agriculture Organization of the United Nations.
[3]. Ministry of Agriculture RI (2022). *StrategiPeningkatanProduktivitasPertanianNasional*. Jakarta.
[4]. Hartemink, A. E., & McBratney, A. (2008). *Soil science and the future*. Geoderma, 148(2), 1–7.
[5]. Sanchez, P. A. (2019). *Properties and Management of Soils in the Tropics*. Cambridge University Press.
[6]. World Bank (2020). *Transforming Indonesian Agriculture: Towards Inclusive and Sustainable Development*.
[7]. Zhao, Y., et al. (2018). *Application of humic substances to improve soil properties and plant growth in degraded lands*. Agriculture, 8(10), 161.
[8]. BBLSLP, Sifat Fisik Tanah danMetodeAnalisisnya. 2006.
[9]. Zhao, B., et al. (2018). Response of leaf area development and photosynthesis to nitrogen application in wheat. Journal of Integrative Agriculture, 17(2), 375–386.
[10]. FAO (2021). The State of the World’s Land and Water Resources for Food and Agriculture – Systems at Breaking Point. Food and Agriculture Organization of the United Nations.
[11]. Marschner, H. (2012). Mineral Nutrition of Higher Plants. 3rd Edition. Academic Press.
[12]. Havlin, J.L., Tisdale, S.L., Nelson, W.L., & Beaton, J.D. (2014). Soil Fertility and Fertilizers. 8th Edition. Pearson.
[13]. Yoseftabar, S. (2013). Effect of nitrogen and phosphorus fertilizer on some agronomic traits of rice varieties. International Journal of Agriculture and Crop Sciences, 5(15), 1623–1627.
[14]. FAO (2021). The State of the World’s Land and Water Resources for Food and Agriculture – Systems at Breaking Point. Food and Agriculture Organization of the United Nations.
[15]. Havlin, J.L., Tisdale, S.L., Nelson, W.L., & Beaton, J.D. (2014). Soil Fertility and Fertilizers. 8th Edition. Pearson.
[16]. Marschner, H. (2012). Mineral Nutrition of Higher Plants. 3rd Edition. Academic Press.
[17]. Zhao, B., et al. (2018). Response of stem growth and yield components to nitrogen management in crops. Journal of Integrative Agriculture, 17(3), 625–636.