Siam Weeds impacts at Oil Palm population growth in Indonesia

Number of pages: 12

1. Introduction

Oil palms, or Elaeis guineensis, are very important for the world, both for economic and environmental reasons. Economically, it produces high-quality oil, which is used in many human consumptions, like food products, detergents, cosmetics, and even biofuel to an extent, which reflects at the supply of 40% of traded vegetable oils, and a big daily consumption of more than 3 billion people, mainly in Asia (Russell 2023). Additionally, it creates employment for millions of smallholders, like in Indonesia (4 million smallholders). (Russell 2018). Other than those benefits, environmentally, Oil palms also have a great importance into enhanced disease resistance, a greater climatic resistance, continuous ground cover, and a way of protecting the soil against erosion. Nonetheless, it is especially important in Asia, as Indonesia and Malaysia are the leaders in plant's production, showing how it is valuable for those countries, and even the overall continent. (Russell 2023)

Considering this, there is a growing concern in regards to invasive species which affect Oil palms, and one of the most notable ones are the Siam Weeds (Chromolaena odorata), a toxic type of plant which prevent the establishment of other species, because of competition and allelopathic impacts, as well as altering the diversity of natural plant communities. Those also heavily impact on animal populations, as it replaces food plants, and makes nesting habitats unsuitable. It is widespread in Asia, showing its great effects into other parts of the world, even with its origins from tropical America ("Chromolaena odorata", n.d.).

Moreover, the effects Siam Weeds have on other species can also affect Oil palm plantations, since they both are tropical plants, with a heavy influence in the Asian continent. It does have the benefit of reducing deforestation, and habitat loss for endangered species, such as tigers and rhinos, effects caused by the constant Oil palm plantations spread ("What is Palm Oil? Facts About the Palm Oil Industry", n.d.). But it impacts on the plant's environmental and economic positive aspects, which are also very relevant to consider.

In that context, this research aims to evaluate the following research question: "**How does the invasive species of Siam Weeds impact the population growth of Oil Palm in**

Indonesia?", seeing that Oil palms has a great importance on Indonesia, and the increasing presence of Siam weeds in the Asian continent, as those are factors which make the exploration of how the population growth of Oil palms more relevant. In addition to that, there is a main objective of determining if there is a strong or weak correlation between the variables of Siam weeds, and Oil palm population growth, as well as the advantages and disadvantages of those effects.

Personal interest

I chose this topic because invasive species have always interested me in biology, and also how strong can those species affect existing species. This impact into the survival of different species is something that always grabbed my attention, and because of the worldwide importance Oil Palm has, especially because of the economic contribution this plant has. So, because of my Oil Plam interest I chose one country where this plant is very important, Indonesia. This choice was also due to the fact that I had never performed any study in that region of Asia, so I wanted to challenge myself and study something I never attempted before.

2. Background Research

2.1 Oil Palms growth conditions

Oil palms require specific conditions to grow and prosper. Firstly, even being able to grow in a high variety of soils, it has to have specific characteristics so that the oil can have an optimal growth. Those characteristics include a deep and easily penetrable soil, with good moisture retention and free drainage, as well as a more appropriate soil type for the oil's growth, this being type I- a type of soil which is based on well structured soil, with 15-35% clay content, and a unrestricted rooting volume. Other that that, there is also specific chemical and nutrient characteristics which the soil must have for Oil Palm growth (Verheye, W. 2010), which are based on the following in table 1:

SOIL CHARACTERISTIC	OPTIMAL RANGE
C/N Ratio	Near 10 on the soil surface
Exchangeable K+	0.15 - 0.20 me/100g soil
Available P	3 - 5 mg/kg soil;
Mg/K and Ca/K	Above 2
pH	Higher than 4.5

Table 1: Chemical and nutrient characteristics for Oil Palm growth
Source: Made by the author based on: (Verheye, W. 2010)

Additionally, climate factors are important to understand Oil Palm growth. Firstly, the ideal temperature characteristics for the oil's growth is based on the least fluctuations possible, with high temperatures (which are the most favorable ones). Below 18°C growth is stopped, making the optimal daily temperature 27-28°C, where maximum means should be 30-32°C, and minimum ones 21-24°C. However, at colder stations the temperatures cannot be below 15°C, since investigations in Congo and Guinea can cause a disease called "heart root", which affects mainly trees 5-8 years old, and it can lead to the killing of the trees. (Verheye, W. 2010). The rainfall and moisture is also heavily important for the oil's growth, since there are specific requirements for that as well. At first instance, the rainfall periods should be 150/mm per month, and dry periods less than 2-3 months, with an air humidity of 75% during the year. The best yields of Oil Palm are produced within 2,000mm rain per annum, and rainfalls above 2,5000mm are already considered unfavorable. Moreover, the most favorable humidity for Oil Palm growth is 75-100% humidity, and the moisture deficit should always be considered, since the deficit that is ideal for optimal production is between 0-150mm, above that growth begins to become unfavorable, with deficits above 500mm being considered the most unfavorable ones. (Verheye, W. 2010)

Those factors are essential to understand what affects Oil Palm growth, as Siam Weeds will affect more directly the soil conditions. However the temperature and moisture factors are important because of the consideration that those factors may have affected more Oil Palm growth than Siam Weeds in specific years, so this investigation needs to consider both factors for the analysis.

2.2 Siam Weeds impacts as a invasive species

As mentioned before, Siam Weeds have severe impacts on different plant species due to its invasive nature. Its impact is based on replacing the natural secondary succession, and becoming the dominant fallow species. Firstly, Siam Weeds can form dense thickets which outcompete and slowly kill/outcompete native plants, which leads to the killing of biodiversity. A similar action is performed by those weeds to outcompete agricultural crops, which are one of the ways such affect Oil Palms. Other ways are based on its correlation with the pH of the soil, where they are more present in areas with neutral to acidic soils, which affects how this invasive species has a widespread and fastly invading biosystems, and even infests entire countries- like East Timor. There is also some association with climate, more specifically rainfall, humidity and temperature, as those factors can affect how much Siam Weeds are present at a specific location. (Dandjlessaa et al. 2021)

Additionally, one of the most important factors which enable Siam Weeds to establish its invasiveness, is its production of allelochemicals, which are how the plant inhibits the growth of other plants and establish its competitive advantage, which given that the weed has a big ability of spreading and taking over ecosystems, it is very useful and very used by this plant. Also, the lack of natural enemies are more ways which ensures the weed survival, and competitive advantage over the location it is acting on. (Dandjlessaa et al. 2021)

3. Methodology

To find an answer for this research question, a literature review will be performed regarding Oil Palm, Siam Weeds, and the interaction between both of them. This will be based on scientific journals, agricultural reports, and government reports which should give an understanding of the effects Siam Weeds have on Oil Palms. Such sources were chosen based on their reliability, and how many times they were cited. So scientific journals were evaluated on how much data it considered, and the institution they were from. The governmental reports were directly from the Indonesian governments, or if relevant from other governments from other countries. For the meteorological information, the site used was Weather and Climate, a site which contains that kind of information for every place in the world.

Moreover, an Analysis of Variance (ANOVA) test will be done, to compare variables which are related with the regions with the highest Oil Palm plantations in Indonesia, those being: the numbers of hectares of Oil Palms, the average rainfall, the average humidity levels, the average pH levels, the average temperature, and a spiculated density level of siam weeds, all on those regions. The latter has to be speculated since there is no information regarding the siam weeds density levels at those regions, so the way to speculate was to see how siam weeds normally react to the variables being analyzed at different regions (such as Nigeria), and speculate how the density level would be in Indonesia. Those variables were chosen since they affect Oil Palm growth, and Siam Weeds influence more predominant, so they are ones which will give a better understanding for this investigation. Also, the test was done using technology, more specifically the Social Science Statistics site, a website focused on performing every statistical test, and the most reliable one since it provides step by step explanation on how to use the tests, and it also is the most used one for performing the actual tests.

It is important to note that this interpretation and discussion of the results will be heavily based on the literature review, as well as with the information from the background research. This method should give a complete outlook of the effects Siam Weeds have on Oil Palms, and answer the research question properly. Also, every variable from the results from the ANOVA will be present at Appendix 1, and the critical value for the ANOVA- test will be based on the table present at Appendix 2.

4. Analysis

4.1 ANOVA test

For the ANOVA test, the following hypothesis will be tested:

Null hypothesis (HO): The Siam Weed density level does not affect the size of Oil Palm growth.

Alternative hypothesis (H1): The Siam Weed density level directly affects the size of Oil Palm growth.

Additionally, the significance level chosen is 0.05, in order to find which hypothesis is accepted. Also, the data present in table 2 will be the one this ANOVA test will be based on:

REGION WITH THE LARGEST OIL PALM PLANTATION IN INDONESIA	**NUMBER OF HECTARES OF OIL PALM PLANTATIONS IN INDONESIA PER REGION (IN MILLIONS**	**AVERAGE RAINFALL PER YEAR IN INDONESIA PER REGION (IN mm)**	**AVERAGE HUMIDITY LEVELS (IN %)**	**AVERAGE pH LEVELS IN THE SOILS AT EACH REGION**	**AVERAGE TEMPERATURE IN EACH REGION (IN °C)**	**SPICULATED DENSITY LEVELS OF SIAM WEEDS (MEASURED IN HIGH/MEDIUM /LOW)**
Riau	2.87	164.15	83.16	5,2	28.43	Medium
Central Kalimantan	2.21	150.76	79.37	5,2	28.68	High
West Kalimantan	2.07	197.49	82.66	5,2	28.56	Medium
North Sumatera	1.37	153.41	82.67	5,2	27.46	Medium
East Kalimantan	1.37	97.22	78.32	5,2	28.44	High
South Sumatra	1.13	162.03	81.62	5,2	28.57	Medium
Jambi	1.07	141	82.73	5,2	26.91	Medium

Table 2: Data for the ANOVA test.
Source: Made by the author based on: (Dandjlessaa et al. 2021), ("Average Rainfall in Indonesia", n.d.), (Siahaan 2024), (Khusrizal, Yusra, and Perangin angin 2020)

The ANOVA test gave the following results (table 3, and 4):

	NUMBER OF HECTARES OF OIL PALM PLANTATIONS IN INDONESIA PER REGION (IN MILLIONS)	AVERAGE RAINFALL PER YEAR IN INDONESIA PER REGION (IN mm)	AVERAGE HUMIDITY LEVELS (IN %)	AVERAGE pH LEVELS IN THE SOILS AT EACH REGION	AVERAGE TEMPERATURE IN EACH REGION (IN °C)	TOTAL
N	7	7	7	14	7	42
∑X	12.09	1066.06	570.53	49	197.05	1894.73
Mean	1.7271	152.2943	81.5043	3.5	28.15	45.113
$\sum X^2$	23.5815	167797.1776	46522.2867	203	5549.7591	220095.8049
S.D	0.6709	30.1174	1.8994	1.5566	0.6833	57.301

Table 3: Data from the ANOVA test.
Source: Made by the author based on: (Dandjlessaa et al. 2021), ("Average Rainfall in Indonesia", n.d.), (Siahaan 2024), (Khusrizal, Yusra, and Perangin angin 2020)

SOURCE	SS	dF	MS
Between Siam Weeds density levels	129118.5923	4	32279.6481
Within Siam Weeds density levels	5500.9799	37	148.6751
Total	134619.5722	41	32428.3232

Table 4: Data from the ANOVA test.
Source: Made by the author based on: (Dandjlessaa et al. 2021), ("Average Rainfall in Indonesia", n.d.), (Siahaan 2024), (Khusrizal, Yusra, and Perangin angin 2020)

Other important results include:

f-ratio value= 217.11532, and p-value= 0.00001

4.2 Discussion

From only the ANOVA-test results, it is possible to see that the f-ratio value>critical value, since 217.11532>2.63, and the significance level> p-value, as 0.05>0.00001. This indicates that **H1** is accepted, and **HO** is rejected, meaning that the siam weed's density levels directly affects the size of oil palm growth in Indonesia. It is important to note that each value (f-ratio and p-value) were vastly different from the critical value and the significance level, showing that **H1** was strongly accepted due to this big difference, emphasizing how the oil palm population growth is affected by siam weed impacts.

Other than this, the results and information from the background research also gives more conclusions and analysis to be drawn. Firstly, from table 3 the means show that each variable has a very high mean, showing that the regions analyzed in Indonesia are more favorable for siam weeds to invade, and affect oil palm growth. For instance, the mean pH level, which is 3.5 (acidic soil), being the pH level which is the most favorable type of soils for siam weeds to invade, aligns with **H1.** But this mean from the pH level also shows disadvantages for oil palm, since as mentioned the ideal pH level is at minimum 4.5, so this can be another factor which can affect oil palm populational growth.

The mean also shows that those Indonesian regions analyzed have overall conditions, like humidity levels (81%, being at the range if best humidity levels for oil palms to grow, 75-100%) that are also very favorable for oil palm plantations, which can be interpreted as a big threat for oil palms, since the regions were the conditions are most favorable for oil palm to develop are also beneficial for siam weeds to be invasive, and probably siam weeds will continue to follow the oil palms in Indonesia due to such conditions. This also enlarges the danger to oil palms, and emphasizes the care those need to have for siam weeds to not produce its allelochemicals, and perform its other invasive actions towards the oil palms. The fact that in general the spiculated density levels of the siam weeds in every region varies from high to medium also supports this analysis of the means, and presents more evidence for the favorable conditions Indonesia has for siam weeds to endanger oil palm populational growth.

Moreover, even though the means indicate that the conditions are mostly favorable for oil palm and siam weeds, the S.D indicates that there is some variability within the rainfall, humidity and temperature variables, as those are considerably dispersed values if compared to their means, as well as the number of hectares from the plantations. The pH level on the other hand did not have a very different standard deviation from its mean. This can be interpret as additional impacts the variables mentioned can have on oil palm and siam weeds, since this shows that such variables can change in different regions, which may be more favorable for siam weeds, or oil palm, but it needs to be considered when an oil palm plantation is set, since depending of how temperature, and rainfall vary, it can be a safer space for oil palm to grow, rather than for siam weeds. This can be one of the ways to avoid siam weeds impacts at oil palm growth, even with Indonesia being mostly a favorable region for the weed to spread (as table 2 aligns with the information from the background research regarding siam weeds). Additionally, as mentioned the standard deviation of the size of oil palm plantations in hectares is also considerably different from its mean, which shows that there is also variability at the size of oil palm plantations, with some being smaller or bigger than others. This may hinder that smaller plantations will be more endangered than the bigger ones, since siam weeds will kill the plantations more rapidly, but again the conditions of the smaller ones may be more adequate for oil palms tha for siam weeds, like explained before with the rainfall and temperature variables, but the higher risks exist for those smaller plantations nonetheless.

The high SS between siam weeds density levels (129118.5923) also indicates that there is a substantial difference at oil palm plantations sizes across different siam weeds density levels. This can indicate that the size of the plantations can be smaller in regions with higher siam weeds densities, which although not a pattern that can be identified in table 2, since some regions like East Kalimantan, with a high siam weed density level, but a 1.37 million hectares oil palm plantation size (low compared to the other regions), and others such as Central Kalimantan, that also has a high siam weed density level, but a 2.21 million hectares oil palm plantation size (the second highest), showing that there is no trend to be drawn on that matter. But if there is a considerable oil palm plantation size variation between the density levels, this pattern may occur, since high siam weeds density levels may have greater impacts in plantations compared to medium densities of siam weeds, especially due to the weed nature of widespread and rapid biosystems invasions. Those factors result on possible dangers to oil palm plantations, since depending on how this variation on oil palm plantation size is compared to high or medium density levels, the plantations with higher siam weed density levels will suffer heavily from the invasive species effects, and further care into setting oil palm plantations need to be considered so that it is not made in regions with a high siam weed density level.

Within siam weed density levels SS was also high (5500.9799), which indicates that oil palm plantations sizes have variabilities within regions that have the same siam weed density level. This, although not as high as the SS between siam weed density levels- resulting in variations in oil palm plantations to vary more in regards to different siam weed density levels- still is an important factor, since it shows that even when siam weeds density levels are equal, variability in oil palm plantation sizes still exists, which can be a problem especially if the siam weed density levels are usually medium to high (like the spiculated densities for the regions analyzed in table 2). Both of the SS show that either way, there is a variation in oil palm plantations and density levels of siam weed, and depending on what those density levels are, and the size of oil palm plantations, the latter will suffer great danger from the invasive species' effects.

5. Conclusions

To finally answer the research question: **"How does the invasive species of Siam Weeds impact the population growth of Oil Palm in Indonesia?"**, the invasive species of siam weeds have direct effects at the populational growth of oil palm in Indonesia, as shown by the ANOVA tests results, as well as the post analysis from the different values analyzed, such as means and standard deviations.

A pattern found at the analysis is that siam weeds will most probably continue to endanger oil palm plantations because of the main conditions at the Indonesian regions analyzed, which shows that the country is very favorable for both oil palms and siam weeds. However, this endangers oil palm especially due to the variability both the siam weed density and oil palm plantations sizes have, as this can cause implications depending on how those variations work. If small oil palm plantations have high siam weed density levels, then most probably this plantation will have most of its oil palm killed. (Dandjlessaa et al. 2021), (Verheye, W. 2010)

Moreover, Siam Weeds endanger Oil Palm plantations due to the invasive species ability to alter soil pH and moisture levels, which are crucial for Oil Palm health. Thus, since Siam Weeds thrive in more acidic soils, which matches the mean pH level of 3.5 found in regions with high Siam Weed density, they further endanger Oil Palms because the appropriate pH level for those is 4.5. On that note, the high variability observed in Oil Palm plantations' size and Siam Weeds density levels across the Indonesian regions, represents how those interactions impact directly at the plant’s health, due to Siam Weeds allelochemicals and competitive factors. Those factors exemplify further how much the invasive species impacts Oil Palm health, and it confirms impacts established at the background research. (Dandjlessaa et al. 2021), (Verheye, W. 2010)

The specific effects siam weed has at oil palm are mostly related with how they attack other species, this being (as mentioned before) the production of allelochemicals to inhibit the growth of other plants, as well as the lack of competitiveness especially in Indonesia, were what does exists is a big target for the invasive species (this being oil palm) (Dandjlessaa et al. 2021), (Verheye, W. 2010). However if closer and careful management is done to first plant oil palms in regions which the siam weed density is the lowest, and ensure it to also be a big plantation (so that it takes longer for the siam weed to kill oil palms). This could open space for Indonesian agricultures to control siam weed in the country, especially in the most favorable regions for the weeds’ development, and even regions where siam weeds have higher densities, since they are a great danger to a very important part to the country’s economical and environmental factors. With this greater management of the plantations, the biggest advantage siam weeds have in Indonesia could be abolished, since the invasive species has a “comfortable” position in Indonesia due to the environmental conditions that favor them which was explained at the analysis. Those factors enable the weed to perform its traits and effectively impact the population growth of oil palm.

Limitations and further research

This research could have benefited more if it was done directly at Indonesia, with an analysis at the different regions from the country, and a closer look at more specific effects siam weeds have at oil palms there. The information from siam weeds at Indonesia was also limited, and this different approach could have made the assignment better and given more insights and perspectives into the research question. Such lack of information was a big limitation since I had to find data from other regions and simulate an approximate data for Indonesia, which can make my research lose some preciseness and accuracy, something an field research at Indonesia would have avoided, since I would have precise values. This may have impacted the ANOVA, and consequently the analysis made, and also if other variables were available, such as Exchangeable K+ (one important factor for oil palm growth as mentioned at the background research), it would have benefited the research, and maybe the results would have changed significantly. Another limitation is the lack of further information on siam weeds and its impacts as an invasive species, since research articles directly about them also did not have much information other than the one presented at the background research. More siam weed information could have aggregated to a more complete analysis of this species impacts on Oil palm plantations.

However, the investigation opens space for further researches involving siam weeds and oil palm populations, since with the conclusions and analysis the discussion of how siam weeds could be controlled at Indonesia specifically is a topic that can be further investigated, as well as more specific management agricultors, and even the Indonesian government could make, so that oil palm is preserved. A closer understanding of how the variation of siam weed density and oil palm populational growth works could also be a further research, which would provide deeper insights into the impacts siam weeds have at oil palms, and also a way to better understand how oil palm can be better preserved. But this would only be possible in a field study in Indonesia as well, since there is not enough data-based information for this.

Bibliography

"Average Rainfall in Indonesia." n.d. Weather and Climate. Accessed 07 01, 2024. https://weatherandclimate.com/indonesia/jambi.

"Chromolaena odorata." n.d. Key Search. Accessed March 15, 2024. https://keyserver.lucidcentral.org/weeds/data/media/Html/chromolaena_odorata.htm.

Dandjlessaa, Judicaël, Bénoît Ezin, Norliette Zossou, and Adam Ahanchede. 2021. "Mapping actual distribution of invasive species siam weed and its abundance across biogeographical zones in Benin (West Africa)." *Advances in Weed Science*. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.scielo.br/j/aws/a/npkJ8xpSY38kF4F4NBcbmhg/?format=pdf&lang=en.

Khusrizal, K., Yusra, and A.A. Perangin angin. 2020. "CHEMICAL PROPERTIES OF FIVE SOIL TYPES IN THE INDONESIAN SOIL CLASSIFICATION SYSTEM AT KRUENG MEUEH SUB-WATERSHED, ACEH PROVINCE." *International Journal of Psychosocial Rehabilitation*, (03). chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://repository.unimal.ac.id/5547/1/International%20Journal%20of%20Psychosocial%20Rehabilitation,%20Conference%20Special%20Issue.pdf.

Russell, GE. 2023. "Elaeis guineensis (African oil palm) | CABI Compendium." CABI Digital Library. https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.20295.

Russell, Martin. 2018. "Palm oil: economic and environmental impacts." Epthinktank. https://epthinktank.eu/2018/02/19/palm-oil-economic-and-environmental-impacts/.

Siahaan, Mona. 2024. “Indonesia: provinces with largest planted oil palm areas.” Statista. https://www.statista.com/statistics/1094758/indonesia-provinces-with-largest-area-oil-palm-plantations/.

“Social Science Statistics.” n.d. One-Way ANOVA Calculator, Plus Tukey HSD. Accessed August 1, 2024. https://www.socscistatistics.com/tests/anova/default2.aspx.

“Table of critical values for the F distribution (for use with ANOVA) | Summaries Statistics.” 2022. Docsity. https://www.docsity.com/en/table-of-critical-values-for-the-f-distribution-for-use-with-anova/8825215/.

Verheye, W. 2010. “GROWTH AND PRODUCTION OF OIL PALM.” *UGent Institutional Repository*, 25. file:///C:/Users/Usuario/Downloads/527VERHTEXT_totaal.pdf.

“What is Palm Oil? Facts About the Palm Oil Industry.” n.d. WWF. Accessed March 15, 2024. https://www.worldwildlife.org/industries/palm-oil.

Appendix 1- Explanation of key terms from the ANOVA results

N= Number of observations for each variable

∑X= Sum of the values for each variable

Mean= Average value for each variable

$\sum X^2$= Sum of the squared values for each variable

S.D= Standard Deviation

SS= Sum of squares

dF= Degrees of freedom

MS= Mean square

Appendix 2- Table of the critical value for the F- distribution (for use with the ANOVA)

Critical values of F for the 0.05 significance level:

	1	2	3	4	5	6	7	8	9	10
1	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88	240.54	241.88
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.39	19.40
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14
10	4.97	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98
11	4.84	3.98	3.59	3.36	3.20	3.10	3.01	2.95	2.90	2.85
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49
17	4.45	3.59	3.20	2.97	2.81	2.70	2.61	2.55	2.49	2.45
18	4.41	3.56	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35
21	4.33	3.47	3.07	2.84	2.69	2.57	2.49	2.42	2.37	2.32
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.38	2.32	2.28
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.26
25	4.24	3.39	2.99	2.76	2.60	2.49	2.41	2.34	2.28	2.24
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.17
31	4.16	3.31	2.91	2.68	2.52	2.41	2.32	2.26	2.20	2.15
32	4.15	3.30	2.90	2.67	2.51	2.40	2.31	2.24	2.19	2.14
33	4.14	3.29	2.89	2.66	2.50	2.39	2.30	2.24	2.18	2.13
34	4.13	3.28	2.88	2.65	2.49	2.38	2.29	2.23	2.17	2.12
35	4.12	3.27	2.87	2.64	2.49	2.37	2.29	2.22	2.16	2.11

36	4.11	3.26	2.87	2.63	2.48	2.36	2.28	2.21	2.15	2.11
37	4.11	3.25	2.86	2.63	2.47	2.36	2.27	2.20	2.15	2.10
38	4.10	3.25	2.85	2.62	2.46	2.35	2.26	2.19	2.14	2.09
39	4.09	3.24	2.85	2.61	2.46	2.34	2.26	2.19	2.13	2.08
40	4.09	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08
41	4.08	3.23	2.83	2.60	2.44	2.33	2.24	2.17	2.12	2.07
42	4.07	3.22	2.83	2.59	2.44	2.32	2.24	2.17	2.11	2.07
43	4.07	3.21	2.82	2.59	2.43	2.32	2.23	2.16	2.11	2.06
44	4.06	3.21	2.82	2.58	2.43	2.31	2.23	2.16	2.10	2.05
45	4.06	3.20	2.81	2.58	2.42	2.31	2.22	2.15	2.10	2.05
46	4.05	3.20	2.81	2.57	2.42	2.30	2.22	2.15	2.09	2.04
47	4.05	3.20	2.80	2.57	2.41	2.30	2.21	2.14	2.09	2.04
48	4.04	3.19	2.80	2.57	2.41	2.30	2.21	2.14	2.08	2.04
49	4.04	3.19	2.79	2.56	2.40	2.29	2.20	2.13	2.08	2.03
50	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.03
51	4.03	3.18	2.79	2.55	2.40	2.28	2.20	2.13	2.07	2.02
52	4.03	3.18	2.78	2.55	2.39	2.28	2.19	2.12	2.07	2.02
53	4.02	3.17	2.78	2.55	2.39	2.28	2.19	2.12	2.06	2.02
54	4.02	3.17	2.78	2.54	2.39	2.27	2.19	2.12	2.06	2.01
55	4.02	3.17	2.77	2.54	2.38	2.27	2.18	2.11	2.06	2.01
56	4.01	3.16	2.77	2.54	2.38	2.27	2.18	2.11	2.05	2.01
57	4.01	3.16	2.77	2.53	2.38	2.26	2.18	2.11	2.05	2.00
58	4.01	3.16	2.76	2.53	2.37	2.26	2.17	2.10	2.05	2.00
59	4.00	3.15	2.76	2.53	2.37	2.26	2.17	2.10	2.04	2.00
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99

Source: "Table of critical values for the F distribution (for use with ANOVA) | Summaries Statistics." 2022. Docsity. https://www.docsity.com/en/table-of-critical-values-for-the-f-distribution-for-use-with-anova/8825215/.