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MANAGEMENT (IPM) ON TOMATO PRODUCTION ON SMALLHOLDER FARMERS IN MERU  
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## **Original Research Article**

### **ANALYSIS OF FACTORS INFLUENCING ADOPTION OF INTEGRATED PEST MANAGEMENT (IPM) ON TOMATO PRODUCTION ON SMALLHOLDER FARMERS IN MERU COUNTY, KENYA**

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#### **Abstract**

Horticulture production is one of the key sectors in agriculture. The sector offers opportunities for employment creation, enables access to education and health care, and provides women with economic opportunities in rural economies where the highest production of fruits and vegetables takes place. Despite the numerous economic benefits, pests and diseases remain some of the most significant constraints in this sector. This study investigated the socioeconomic factors influencing the adoption of IPM practices in tomato production by smallholder farmers. The study was conducted in Meru county, Kenya, where five sub-counties were selected. The study assessed the effects of gender, farm size, labor, and access to information. A sample size of 152 smallholder tomato farmers were selected from the study using and target using the stratified random sampling technique and data was collected using a questionnaire. The research findings established that gender type, farm size, labor, access to information, and age of the farmers were negative and significant to the adoption of IPM. The study established that gender type (5%), farm size (5%), labor (5%), and access to information (5%), and age of the farmers (5%) were statistically significant. Additionally, gender type resulted in an increase of adoption of IPM by 43%, farm size by 8%, labor by 11%, while access to information by 40%. The study concluded that different stakeholders should ensure a support system to various IPM practices to lower production costs and encourage adopting the techniques.

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*Keyword: Adoption, Integrated Pest Management, Production, Smallholder farmer, Tomato*

## 1 Introduction

Agriculture is the main sector of Kenya's economy. In 2017, it contributed an average of about 25% of gross domestic product (GDP) and at least 60% of the total labor force employed (Borter, 2017). Agriculture is also responsible for most of the county's export, accounting for up to 65% of merchandise exports in 2019 (Kihoro & Gathungu, 2020). Horticultural production is one of the most critical sectors of the Kenyan economy, contributing 29.5% to the country's economic GDP and contributing significantly to the agriculture GDP (Gathambiri et al., 2021). Horticulture provides women with economic opportunities in rural economies, employment enables access to education and health care, and it's where the production of fruits and vegetables takes place.

Kihoro & Gathungu, 2020 reported that the productivity of the horticultural sector in Kenya is below the optimal potential. The sector's volume was recently recorded as 310.74 million tonnes, which were higher than the previous year. The reduced productivity was contributed by the low adoption of productive technologies, inefficient and untrained extension personnel, pest and diseases, and poor information flow (Rux et al., 2020).

Efforts to improve horticultural production have been focused on adopting improved technologies, which has led to increased allocation of resources to horticultural research. This has stimulated increased technology adoption.

According to Dhakal & Poudel (2020), crop pests have been found to cause substantial losses, and to reduce these losses, small-scale and large-scale producers use chemicals. However, there has been a concern about the chemical residues in the crops, expenditure on chemicals, and environmental effect of the chemicals. This has necessitated the search for sustainable and safer pest control strategies. Integrated Pest Management has been found as a preferred option and provides better options for many damaging pests and provides an opportunity pest and controls pest using fewer chemicals. Abid et al. (2021) argued that integrated pest Management (IPM) is an ecosystem-based strategy that focuses on the long-term prevention of damage of crops by pests through a combination of cultural, chemical, biological, and mechanical controls to suppress pest population levels below those causing economic injury.

Tomatoes are an edible, often red berry of the plant *Solanum Lycopersicum* which belongs in the same family as potatoes,

capsicum, brinjals, and black nightshade (Ha & Thuy, 2020). Some of the leading countries in production include China, India, Egypt, Brazil, Iran, Spain, Mexico, and the USA. The estimated total world production for tomatoes in 2017 was 182,301,395 metric tons, where china contributed to about 33% of the global output (Hayes, 2019).

Africa has a serious tomato problem; however, the total production of tomatoes in Africa is 17.938 million tons, where Egypt produces 8.6 million tons (Ha & Thuy, 2020). The leading countries are Egypt and Nigeria, producing 8.3 million tons and 1.5 million tons respectively every year. In 2017, Kenya's area under tomato was 24,074ha, and the national production was 400,204 metric tons valued at KES11.8 million (Khorram & Ghahderijani, 2020). Tomato is mainly produced in Bungoma, Kirinyaga, and Kajiado, which accounted for 37% (Thomas et al., 2020). In Kirinyaga and Liotoktok. Tomato is produced under irrigation schemes, mainly Mwea and Namelock schemes, respectively. Greenhouse tomatoes have picked with farmers, but the main challenge is the spread of Bacterial wilt, leading to the gradual abandonment of greenhouses (Onyang'o et al., 2016).

In 2012, the HCDA horticulture performance report showed that Meru county is the leading in horticultural production with small-scale farmers venturing into the sector (Baariu & Mulaku, 2015). Most horticultural smallholder farmers in Meru County have formed groups to enjoy economies of scale. Within Meru county is Buuri Sub County, which is prevalently dominated by horticultural farming. The area under study was Buuri constituency. The area is within a semi-arid region; therefore, most of the agriculture is through irrigation. Other crops that have been grown in this area include onions, capsicum, and watermelon. The farmers in this area practice small-scale tomato farming. The major constraint in tomato production is pest and diseases, which has led to fluctuations in production, which has contributed to high losses to farmers. In most cases, synthetic chemicals have been used during production to control and manage pests and diseases. Various tomato production strategies have been brought up through research, but the most promising is IPM in dealing with the serious pest and disease problem hampering tomato production (Ha & Thuy, 2020).

Studies such as evaluating the effectiveness of insect-treated nets as a pest management option that could be used among smallholder vegetable farmers in

the peri-urban, to enhance IPM (Raghutej & Emmanuel, 2021). Factors affecting adoption of Integrated Pest Management technologies by smallholder common been farmers a case study in Bungoma and Machakos county have been conducted in Kenya with the aim of analyzing IPM, but the effect that IPM has on production in terms of yield analysis and pest population analysis has been left out. The study on the effect of IPM on tomato production has determined the impact of IPM practices on the quality and quantity of yield and determine adoption factors of IPM.

In Meru, small-scale tomato production has numerous challenges associated with the poor pest and disease management, affecting the general cost of production, effects of pesticides on population, and low farmers' income. According to Kariathi et al. (2016), most of the tomatoes produced in Meru have high traces of pesticides affecting their marketability in both international, national, and local markets. Ombaso & Luketero (2019) argued that out of the 9200 tonnes of tomatoes produced in 2017, only 400 tonnes had the required measure of pesticide content. Poor application of IPM program in Meru has negatively affected the tomatoes farmers' economy and income in Meru county. Nevertheless, tomato production remains one of the

significant agricultural activities in the county in the provision of livelihoods for small-scale farmers. Despite having efforts by different key players in the county to influence the adoption of IPM, there is low adoption of the practice, with the majority of the farmers undergoing hire production cost associated with usage of pesticide to control pests on their tomato farms. Different scholars have researched institutional factors influencing the adoption of IPM programs in the production of tomatoes in Meru county, but limited studies have focused on the socioeconomic factor influencing the adoption of the program. This article focused on an in-depth investigation of socioeconomic factors influencing the adoption of the IPM program.

## 2. Methodology

### Study Area

Meru county lies east of the Mt. Kenya, and it saddles the equator lying within 0° 6' North and about 0° 1' South and latitude 37° west and 38° East (MCIDP, 2013). The county has a total area of 693,620 hectares (Ha), out of which 177,610 Ha is gazette forest (Nkatha et al., 2020). The county shares borders with Tharaka Nithi to the South, Isiolo to the North and East, Laikipia and Nyeri counties to the west.

The study was carried out in Buuri constituency, Meru county.

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It is characterized by high agricultural productivity attributed to favorable climatic conditions and fertile lands. High-input, rain-fed agriculture complemented by irrigation is the main source of livelihood in the county. Meru county is parceled into four agro-ecological zones (AEZs) ranging from upper highlands (2230-2900m above sea level), Lower highlands (1830-2210m above sea level), Upper midlands (1280-1800m above sea level), and lower midlands (750-1300m above sea level) (Ekabu, 2019).

#### **Research Design**

In the study, descriptive design was employed in the description of the status of the study's variable. A descriptive survey was appropriate for this study because it conducted numerical descriptions of the target population's trends, attitudes, and opinions regarding the effect of IPM on tomato production (Pathak & Singh, 2019). The descriptive design was also effective in describing the traits of the tomato farmers in the entire Meru county. The use of secondary and primary data was adopted where secondary data was acquired from books, the internet, and journals, while primary data was collected through structured questionnaires. Tomato farmers were supplied with a questionnaire that was to fill with the assistance of research enumerators. The questionnaires

sought to determine the influence of gender, farm size, labor, and access to information in adopting the IPM program.

#### **Sample Size and Sampling**

The target population for the study was the 2450 small-scale farmers producing tomatoes who work with the aid of extensionists from Real IPM LTD. The beneficiaries in the area share common beliefs and values and practice small-scale farming. Most of the farming was by irrigation due to unreliable rainfall. Stratified sampling was applied to select respondents from different wards in Buuri sub county because the population was homogeneous where the five sub-counties were made individual stratum. Similarly, a simple random sampling method was used to select individual respondents from the sub-county to avoid biasness and give an equal chance for the farmers to participate in the study. The study area had 2450 farmers practicing Tomato production. A sample size of 152 respondents was appropriate. The sample size was obtained using Yamane (1967) formula:

$$n = \frac{N}{1+N(e)^2}$$

Whereby:

n=size of sample required.

N=size of the total population as 245

e=Acceptable error given as 0.05

The target population was 152 and was calculated as follows:

$$n = \frac{2450}{1+245(0.05)^2}=152.$$

### Data Collection

The questionnaires were captured different data about factors influencing the adoption of the IPM program in Meru county. The factors influencing the adoption of IPM were addressed in the questionnaire. The study ensured validity by visiting Agricultural Extension Office in Meru county. Additionally, Cronbach Alpha was calculated, and a value of 0.80 was obtained, thereby noting that the items used in the questionnaire were worthy of investigation. The three ethical principles of the fundamental assumption that include consent, fidelity, and confidentiality, were applied in the study. Therefore, all data collected from the respondents was used only for the purpose of the proposed study with no reference to particular respondents. Finally, all secondary data used in the research were acknowledged and cited in the reference section of the study.

### Data Analysis

Statistical Package for Social Science (SPSS) version 25 was used to analyze the

data collected from the tomato farmers in Meru county. Descriptive statistics were used to provide interpretation for analyzed data. This study estimated farmer's adoption decision of IPM practices by using a logistic model. The binary logistic response variables and investigates the relationship between independent variables and the log odds of the binary outcome variable. The factors that influence a farm household's decision to adopt Integrated Pest Management technologies were estimated.

### 3. Results and Discussions

The descriptive results show that most of the sampled farmers were males, who consisted of 63.8%, while only 36.2% were female (Table 1). The findings of the journal agreed with Dhakal & Poudel (2020), who noted that the majority of the farmers are male. According to the report, the male was involved in most of the marketing activities of agricultural commodities. Similarly, the results of the journal were in agreement with an article by Dara (2019), who noted that males play a crucial role in farming practices. However, the report differed from the study conducted by Ghosh et al. (2021), who revealed that most of the farm activities are undertaken by females.



Table 1: Characteristic of Smallholder tomato farmers.

Variable		Frequency	Percent	Mean	Standard deviation
Gender	Male	97	63.8	1.36	0.482
	Female	55	36.2		
Age	20-30 years	27	17.8		
	30-40 years	36	23.7		
	40-50 years	45	29.6	2.84	1.287
	50-60 years	22	14.5		
	60-70 years	22	14.5		
Access to Information	Yes	10	6.6		
	No	52	34.2	2.68	0.817
Labour	Family labor	29	19.1		
	Casual labor	54	35.5	2.26	0.761
	Both	69	45.4		
Land size	1/4 acre	25	16.4		
	1/2 acre	32	21.1		
	1 acre	36	23.7		
	2 acres	24	15.8	3.22	1.645
	3acres	18	11.8		
	4acres	12	7.9		
	5acres	5	3.3		

According to Egwuonwu & Iwunwanne (2020), females are involved in land preparation, planting, weed, spray, and harvest. The land allocated for tomato farming was less than 5 acres, with the majority having 1 acre represented by 23.7%. The farmers grew a wide range of horticultural crops, including cabbage,

onions, tomatoes, carrots, capsicum, etc. However, a higher share of farmers, 79%, grew tomatoes and thus was ranked as the most critical crop (Table 1). The result of the study concurred with the findings of Dara (2019), who reported that most of the small-scale allocated less land to different horticultural crops in their farms. On the other hand, the study's findings were

against the results of Cushman (2016), who reported that most small-scale farmers have land allocated to their crops of more than 5 acres. This report noted that most of the farmers allocate small portions of land to maximize the farms they have and produce a variety of crops. Similarly, the study also established that most small-scale farmers have small farms associated with subdivision of land due to inheritance.

The study also revealed that farmers utilized both hired and casual labor, represented by 45% in production tomatoes. Similarly, the study established that despite farmers using both forms of labor, casual labor was the most used (35.5%), while hired labor represented 19.1% (Table 1). The study's findings agreed with Dhakal & Poudel (2020), who reported that most of the farm activities for small-scale farmers are assigned to casual family members. According to Kihoro & Gathungu (2020); Holland et al. (2021), family labor is affordable and accessible to different activities such as land preparation, planting, weeding, spraying, and harvesting the farm. However, the findings of this study were not in line with the results of Saeidi (2012), who noted that most farm activities are undertaken by hired labor. This study noted that the average number of casual laborers was

three workers. Using both family and casual labor proved very affordable by reducing the number of paid casual workers, contributing to reduced production costs.

This study established that most Meru farmers depend on farming (48%), while business, formal employment, and informal employment represent 18.4%, 15.1%, and 18.4% representatively (Table 2). The findings of this study were consistent with Doğan et al. (2020), who noted that the majority of small-scale farmers depend on farming as their primary source of income due to their low levels of education. Furthermore, the finding of this study was against the results of Galt et al. (2016) of who noted that most of the farmers had diversified their sources of income and introduced other none farming activities to support the low income from agriculture. The study also sought to establish the amount spent by farmers on the application of chemicals such as inorganic fertilizers. The study found that 61.8% of farmers spend between sh 15000- sh 20000 on the purchase of pesticide per season to control pests which represented a level of spending keeping in mind that most of them have small pieces of land (Table 2). The study's findings were in line with

Holland et al. (2021), who noted that the majority of the farmers have turned to large spending on chemicals to boost their productivity. Furthermore, the finding of this study was against the results of Saeidi

(2012), who reported that the majority of the farmers had reduced the application of chemicals and adopted IPM.

Table 2: Source of Income, Expenditure on Pesticide and Application of Fertilizer

Variable	Frequency	Percent	Mean	Standard deviation
Source of income				
Farming only	73	48		
Formal employment	23	15.1	2.072	1.18546
Informal employment	28	18.4		
Business	28	18.4		
Expenditure on pesticide sh1000-sh5000	31	20.4		
Sh5000-sh10000	94	61.8	2.013	0.70932
Sh10000-sh15000	21	13.8		
Sh15000-sh20000	6	3.9		
Fertilizer application				
Organic Fertilizer	9	5.9		
Inorganic Fertilizer	97	63.8	2.243	0.5519

According to Dara (2019), the reduced application of chemicals resulted from the benefits realized by IPM. This study noted that farmers who practiced IPM gradually reduced their pesticide use over a period of 2-3 years which was contributed by the combination of measures aimed at lowering pests population and further use of bio-pesticides that were found to have no resistance by the pest. However, farmers argued that chemical pesticides played a major role in crop protection but

resulted in sickness due to excessive usage of pesticides by farmers and farm workers. The side effects of the pesticide use were; breathing difficulties, allergy, vomiting, skin burns, and headache. This study also found out that farmers largely depend on pest and disease control chemicals for their production. Pesticides for pest control were used throughout production, and this contributed the largest share of the cost of production.

### Effects of IPM on Smallholder Tomato Farmers.

The effect of IPM was accessed in terms of yield, cost of production, and net returns. Table 3 presented the results of comparison between an IPM adopter and Non-adopter in terms of yield, cost of production, and net returns. From the study, there was a comparison of yields between IPM adopters and non-IPM adopters. This study revealed that IPM adopters have higher yields than farmers who carry out the conventional farming method (Table 3). The findings of this study were in agreement with the results of

Table 3: Comparison of yields, net returns, and cost of production between an IPM Adopter and a Non-IPM Adopter

Variables	¼ Acre	½ Acre	1 Acre	2 Acres	3 Acres	4 Acres	5 Acres
Average Yields /Acre. (tons)							
IPM adopter	3	6	11.5	21	36	44	58
Non-adopter	2.6	5.2	10	19	31	38	50
Net returns/Acre. (shillings)							
IPM adopter	50000	100000	183000	350000	530000	627000	933000
Non-adopter	24000	48000	86000	133000	307000	313000	467000
The average cost of production/Acre. (shillings)							
IPM adopter	50000	98900	186000	320000	570000	695000	840000
Non-adopter	63000	125000	220000	360000	620000	720000	960000

The findings of this study concurred with Dhakal & Poudel (2020), who noted that there are high returns associated with IPM since the farmers can use alternative

Dara (2019), who noted that the application of IPM increased returns at the farm level in the long run as most of the soil micro-organisms are not destroyed by excessive application of chemicals. However, the study results were against the findings of Holland et al. (2021), who noted that the application of IPM does not have an effect on production. The study also sought to establish the effect of IPM on net returns per acre. The findings of this study indicated that those who were practicing IPM had high net returns compared to the non-adopters (Table 3).

means to control pests and diseases. The findings of this study were against the results of Saeidi (2012), who reported that the IPM does not increase returns unless other production factors support it. This

study indicated that increased net revenue is contributed by spending on pests and diseases, increased resources to the farmer, and better farm management. Similarly, the study sought to establish the cost of production per acre between the adopters and non-adopters of IPM technology. The findings of this study indicated that the non-adopters of IPM had high production compared to adopters of the practice, as shown in Table 3. This study's finding agreed with Rahman (2020), who indicated that the tomato farmers who had not adopted IPM had high production costs due to higher spending on pesticides to control pests and diseases. The research revealed that farmers use large portions of their capital to purchase pesticides and

Table 4: Model Summary

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
153.201 <sup>a</sup>	0.21	0.34

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

The value of the new model indicates a decrease in the -2LL of the obtained model (with explanatory variables); therefore, the new model is a better fit and significant than the baseline model. The new model also indicated that the pseudo-R<sup>2</sup> values were adequate. The R<sup>2</sup> values indicate the variation in the outcome that the model can explain. The model suggested that the model explained roughly 34% of the

control diseases. Moreover, the research established that adoption of IPM results in a gradual reduction in pests and diseases hence saving resources.

#### **Estimation of IPM Technology Adoption.**

Factors influencing farmers' adoption of IPM using the logit model were grouped into two main categories: socioeconomic and institutional categories. Economic factors included; farms size and expected benefits; socio factors were age, gender, schooling years, farming years, and labor employed. Institutional factors include; the number of friends approached/ reached and access to information.

variation in the results, which was a reasonable threshold since it was above 20% (Table 4). Hence, the values indicated no need to make any omission of the variables used in the logistic model during analysis.

The model indicates that gender (5%), farm size (5%), access to hired labor (5%), access to information (5%), and age of the farmer were statistically significant (Table

5). The finding of this study was consistent with Saeidi (2012); Gott & Coyle (2019) noted that gender, farm size, access to hired labor, access to information, and age of the farmer affected the adoption of IPM. Similarly, the study's findings established that gender had a negative and significant ( $p=0.000$ ) effect on the adoption of IPM technology. The study established that males were in apposition to adopt IPM more than females by 43% (Table 5).

Kihoro & Gathungu (2020) reported consistent findings with the study where they stated that males are likely to adopt different agricultural technologies. However, the study's findings were contrasting with Dhakal & Poudel (2020); Dara (2019) noted that females are the people who adopt technologies such as IPM more than males due to lack of credit availability.

Table 5: logit estimation for the adopter of IPM technology (dependent variable: adoption of IPM (1= adopter,0= non adopter)

Parameter	B	Std. Error	95% Interval Lower	Confidence Upper	Hypothesis Test Wald Chi-Square	Exp(B)
Intercept	22.566	35.9742	-18.47	33.602	.000***	0.33
Gender	2.2913	54.5957	-16	66	.000***	0.43
Farm size	0.00381	19.6823	-11.364	2.364	0.03**	0.08
Labour	-0.00316	75.4037	-16.821	48.821	.000***	0.11
Expected benefit	0.00823	20.928	-60.912	11.912	0.041**	1.05
Access to information	-0.00451	63.4686	-74.167	65.903	.000***	0.4

Similarly, the study sought to establish the effect of farm size on the adoption of IPM technology. The study indicated that farm size had a negative and significant ( $p=0.03$ ) effect on the adoption of IPM technology (Table 5). Moreover, the study indicated that a decrease in land size results in an increase in IPM technology

adoption by 8% (Table 5). The findings of this study were consistent with Gott & Coyle (2019), who noted that farmers with small sizes of land were able to adopt the IPM technology since their land was manageable. However, this study's results were against the findings of Dara (2019), who reported that the farmers who had large tracks of land were had high chances

of practicing IPM in efforts to ensure sustainable agriculture. The farmers with small tracks of land noted that they had different methods of controlling diseases and pests. The farmers use the IPM technology to ensure they reduce the effects of pests and diseases using chemicals, mechanical and cultural practices.

The findings also indicated that the hiring of labor negatively impacted the adoption of IPM technology among tomato farmers. The reduction in the labor cost by one unit resulted in an increase in the IPM technology of tomato by 11% (Table 5). Saeidi (2012) produced results that were in agreement with this study's findings. The authors noted that access to labor is essential in the process of IPM since they assist in different pest and disease management. This study noted that family labor was absent, especially during pests and disease control seasons, as the children who offer free labor are in school. IPM is labor-intensive as a lot of labor is required during spraying and undertaking different biological and chemical cultural means to control pests and diseases. Furthermore, the majority of tomato farmers lacked access to skilled laborers to support the IPM technology.

Access to information had a negative and significant effect on the adoption of IPM technology of tomato production. This study indicated that access to information increases the adoption of IPM technology on tomato production by 40% (Table 5).

The study also noted that access to information, knowledge, and skills assists tomato farmers in understanding different IPM technologies applicable in tomato production. Thomas et al. (2010) advanced the similar argument that access to information is crucial in giving institutional mechanisms aimed at disseminating knowledge among farmers to facilitate the adoption of new production technologies.

#### 4. Conclusion

There was a decline in the cost of production of tomato for the farmers who adopted IPM technology. Therefore, it was evident that having access to information on IPM technologies and their benefits in tomato production facilitates adoption since farmers will know the profitability and sustainability of the techniques in the long run. Hence, understanding factors that affect the adoption of IPM practices capable of improving production will help design successful policies and programs to improve tomato production. The use of IPM practices focuses on the farmers'

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economic or social goals to get the production process.

#### COMPETING INTERESTS

#### DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it

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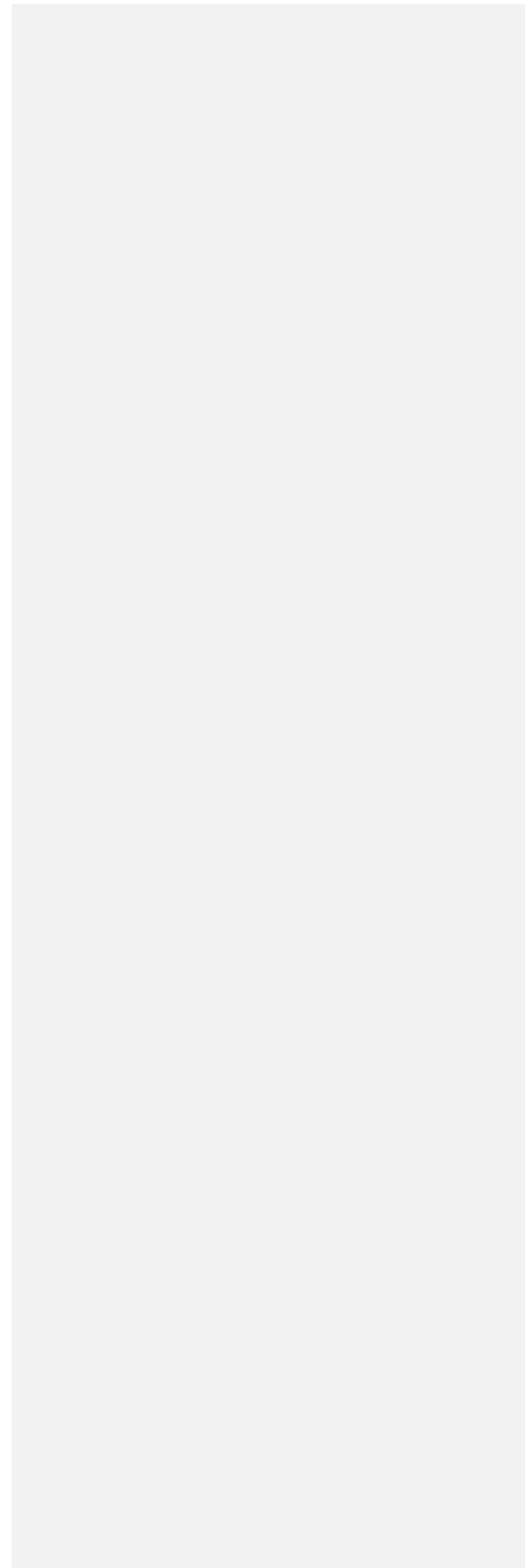
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