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Maize Farmers' Knowledge and Management of Fall Armyworm (*Spodoptera frupigerda*) in Southwest Nigeria

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Abstract

This study investigated maize farmers' knowledge, control methods, and perception of the invasive and highly destructive insect pest, fall armyworm (Spodoptera frugiperda) in southwest Nigeria. A four-stage sampling procedure was employed in selecting 195 maize farmers in the study area. Data were obtained with the aid of structured questionnaire and analysed using percentages, means, standard deviations, and chi-square test. The majority (88.7%) of respondents observed fall armyworm attack within two months after sowing, only 30.8% of them reported total damage to maize plants by fall armyworm. Most (75.9%) of the respondents could describe the destructive larval stage of fall armyworm, 58.5% of respondents exclusively applied synthetic insecticides for fall armyworm management. The most common insecticides used by respondents were organophosphates (37.2%), pyrethroids (29.0%) and avermectins (18.2%). Perception of fall armyworm damage as a serious and worrisome problem was very high (4.82) amongst maize farmers. Strong and significant association ($\chi^2 = 41.3$) was found between farmers' agroecological zones and the severity of fall armyworm damage reported. Integrated pest management approach is a sustainable alternative to the sole

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use of insecticides and should be promoted. Information provided in the study will enhance decision-making for fall armyworm management interventions in southwest Nigeria.

Keywords: *Spodoptera frugiperda,* agroecology, fall armyworm in maize, maize in Nigeria

Introduction

Maize (*Zea mays* L.) is a globally cultivated and important staple food (Food and Agriculture Organization Corporate Statistical Database - FAOSTAT, 2018). Over three hundred million people in sub-Saharan Africa consume and depend on maize for their livelihood (FAOSTAT, 2018). Despite its importance, maize production is constrained by several factors including insect pests like the African maize stem borer (*Busseola fusca*), pink stem borer (*Sesamia calamistis*), and the African armyworm (*Spodoptera exempta*) amongst others (Prasanna et al., 2018).

In 2016, the invasive and highly destructive fall armyworm, *Spodoptera frugiperda,* was first reported in Africa (Ojumoola et al., 2022) and has since primarily damaged maize, thus, further constraining its production on the continent. Adult fall armyworms are moths that can lay eggs directly on host plants unlike the African armyworm species, *S. exempta*. The larval stage is, however, responsible for the actual damage to the leaves, whorl, tassels and kernels of maize plants (Ojumoola et al., 2022). According to ICIPE (2020), this insect pest has already caused eight to twenty million tonnes of losses to maize yield on the African continent.

Unlike Kenya, Ethiopia, Zambia and several other countries in Africa (Kumela et al., 2018; Kansiime et al., 2019), there is a dearth of research-based studies on farmers' perception, knowledge, and management of fall armyworm in Nigeria. Such studies are invaluable because they provide information that enhances the development of effective management strategies for insect pests like the fall armyworm on smallholder farmers' fields (Kansiime et al., 2019). Therefore, the objectives of this study were to assess maize farmers' knowledge, perception and management of the fall armyworm in southwest Nigeria. It was hypothesized that agroecological zones within which maize was cultivated would influence the severity of fall armyworm damage observed by farmers as well as their perception of the damage.

Methodology

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The study was conducted in the southwest region (9° 4' 55.19" N 8° 40' 30.99" E) of Nigeria. The region has three major maize-growing agroecological zones, namely – humid forest, derived savanna, and southern guinea savanna (Ayanlade et al., 2020). All farmers in the study area that cultivated maize in 2016 and or 2017 planting seasons constituted the population of the study.

Maize farmers were selected using a four-stage sampling procedure. In the first stage, the three major maize growing agroecological zones (humid forest in Ogun State, derived savanna in Ekiti State and southern guinea savanna in Oyo State) were purposively sampled. In the second stage, one Agricultural Development Programme (ADP) Zone was purposively selected in each agroecological zone. In the third stage, 50% of ADP Blocks were randomly selected in each ADP Zone. In the fourth stage, respondents were randomly sampled proportionate to size in each ADP Block (Table 1). A total sample size of one hundred and ninety-five (195) maize farmers were, thus, selected across the three agroecological zones. Questionnaire was used to collect information on the respondents' demographics, current maize farming practices, experience with fall armyworm damage, knowledge of fall armyworm identification, control methods employed for the pest, and perception of fall armyworm damage to maize. Questions were mainly closed-ended in a multiple-choice format. Data analysis was done using percentages, means, standard deviations, and chi-square test at 5 % level of significance in IBM SPSS statistics software (2019).

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Table 1: Multistage sampling of maize farmers in Southwest Nigeria

State (corresponding AEZ*)	ADP** Zone	ADP Block (LGA***)
Ogun (Humid forest) 6° 58' 40.1" N 3° 26' 14.9" E	Ikenne Zone	Ikenne
		Sagamu
		Ido/Osi
Ekiti (Derived savanna) 7° 44' 9.2" N 5° 16' 20.6" E	Ekiti North Zone 3	Moba
		Ilejemeje
Oyo (Southern guinea savanna) 8° 12' 51.0" N 3° 33' 46.2" E	Saki Zone	Saki West
		Saki East
		Irepo
		Orelope

* AEZ – Agroecological Zone.
**ADP – Agricultural Development Programme
***LGA – Local Government Areas (LGA)

Results and Discussion

Farmers' Socio-Economic Characteristics

Average maize farming experience in the region (Table 2) was approximately 16 years with most (67.7 %) respondents cultivating maize on a small scale (0.5 – 4.9 ha), as rain-fed (87.7 %), and for the dual purpose of consumption and sales (87.2 %). About 86 % of respondents said they planted maize in both 2016 and 2017 (Figure 2-A). Also, 49.2 % of the respondents planted maize as a sole crop, 35.9 % intercropped it with tubers like cassava, while others intercropped maize with crops like tomato, cowpea, soybean, tomato, and melon (Figure 2-B).

Farmers' Experience with Fall Armyworm Attack and Damage

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In 2016 and 2017, 43.1 % of respondents experienced fall armyworm damage, 31.3 % in 2016 alone, and 25.6 % in 2017 alone (Figure 2-C). Approximately, 70.0 % of respondents reported damage to at least half of their on-farm maize plants (Figure 2-D).

Table 2: Characteristics of maize farmers

Variable	Mean (± SD)	Percentage (n= 195)
Size of land cultivated to maize		
Subsistence (<0.5 ha)		5.6
Small scale (0.5 - 4.9 ha)		67.7
Medium scale (5 - 10 ha)		19
Large scale (> 10 ha)		7.7
Total years of cultivating maize	15.9 (± 9.4)	
Maize farming system		
Rainfed		87.7
Irrigation		1.5
Wetland		1.5
Rainfed and Irrigation		2.6
Rainfed and Wetland		6.7
Purpose of maize cultivation		
Consumption		2.1
Sales		10.8
Consumption and Sales		87.2

Source: Field Survey, 2018

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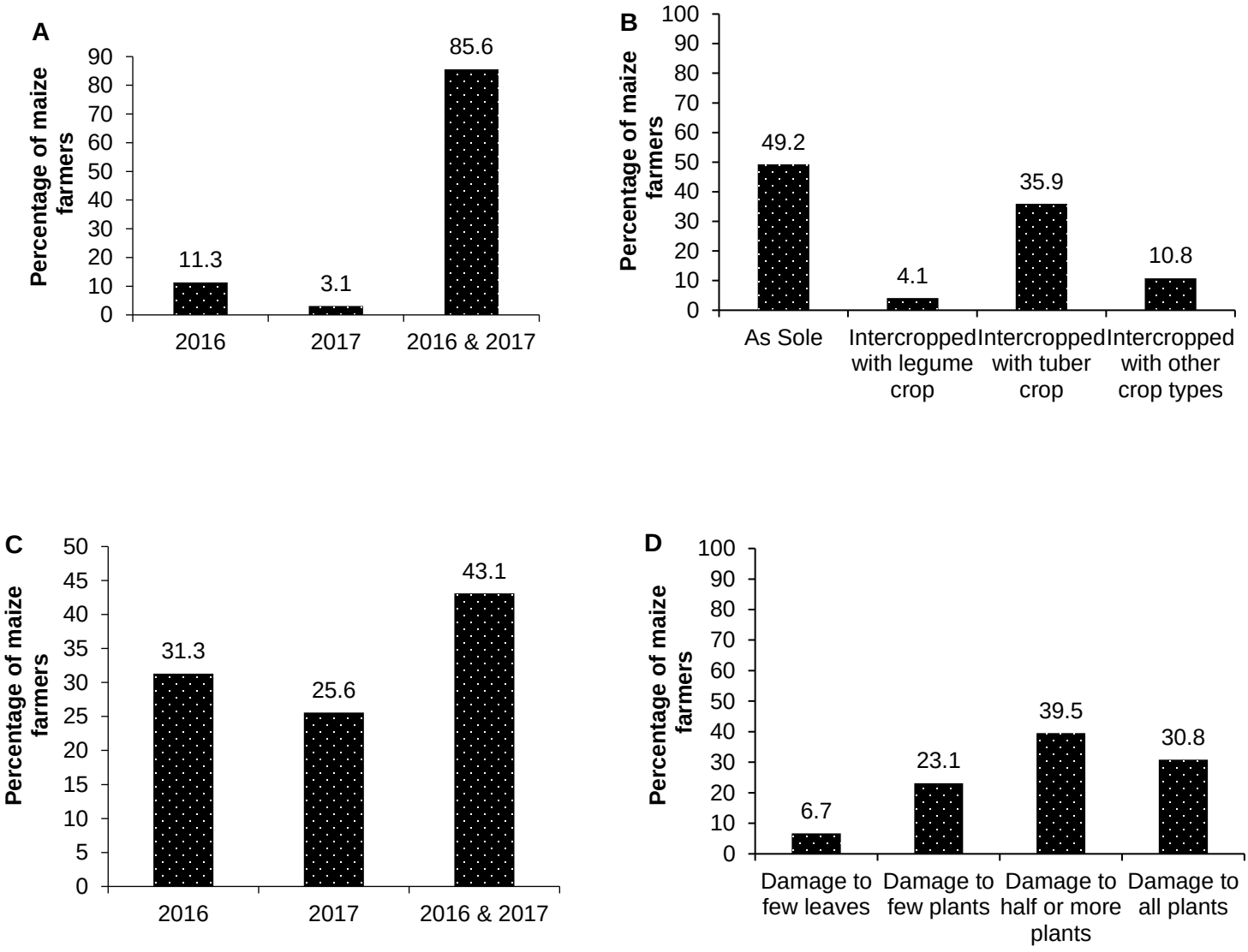

Figure 2: (A) year maize was cultivated; (B) cultivation method when maize was attacked by fall armyworm; (C) year maize was attacked by fall armyworm; (D) Severity of fall armyworm damage to maize

The incidence of fall armyworm damage to on-farm maize in both planting years suggests a seasonal occurrence of the pest in southwest Nigeria. This observation is in line with Prasanna et al. (2018) who surmised that the suitability of the African environmental conditions for fall armyworm reproduction is responsible for the continued presence of the pest as an important agricultural pest on the continent. Amongst those that experienced fall armyworm damage, 45.1 % observed it on less than one month old maize plants while

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for 43.6 % of respondents, plants damaged were between 1 and 2 months (Figure 3-A). This finding agrees with that of Kumela et al. (2018) that maize farmers in Ethiopia and Kenya observed fall armyworm infestation within the first two months after planting with field maize damage of 32 % and 47 % respectively in both countries. There was a relationship ($\chi^2 = 19.0$) between the respondents' method of maize cultivation and severity of observed damage. Similarly, a significant association ($\chi^2 = 25.6$) was observed between the age of maize at the time of attack and the severity of observed damage. This again agrees with Odeyemi et al. (2020) who reported a significant negative correlation between damage severity and maize plant age. Fall armyworm damage severity on maize is associated with farmers' agroecological zone ($\chi^2 = 41.3$).

Farmers' Knowledge of Fall Armyworm

Most (75.9 %) of the respondents described fall armyworm as a small crawling worm (Table 3). Also, respondents were able to distinguish between fall armyworm and stem borer larvae mainly by the feeding and frass deposition behaviour of the former species. Respondents obtained information about fall armyworm from agricultural extension officers (50.5 %), from other farmers (39.4 %), and via radio programs or other media outlets (11.8 %). These results agree with that of Kansiime et al. (2019) that farmers in Zambia were able to identify the destructive larval stage of the pest and that majority sourced information about the pest from extension officer, TV/Radio and through community exchange.

Fall Armyworm Management Strategies

Over half of respondents (58.5 %) sprayed insecticides as the only control method. In contrast, 6.7 % employed only non-chemical control methods while 31.8 % used both chemical (insecticide spray) and non-chemical methods (Table 3). Also, 71.6 % of respondents sprayed insecticides once or twice, 22.2 % sprayed three to four times, while only 6.3 % sprayed more than four times. The majority (57.4 %) of respondents reported moderate effectiveness of insecticides sprayed for control while 32.4 % reported excellent effectiveness. No apparent association was, however, observed between insecticide spray times and insecticide effectiveness ($\chi^2 = 4.2$). According to Kumela et al. (2018) 46% and 60% of farmers in Ethiopia and Kenya, respectively, believed insecticides were ineffective. Amongst those that experienced fall armyworm damage, 45.1 % observed it on less than one month old maize plants while for 43.6 % of respondents, plants damaged were between 1 and 2 months (Figure 3-A). Of the seven insecticide groups sprayed by respondents for fall armyworm control, organophosphates (chlorpyriphos, dichlorvos, and dimethoate) and synthetic pyrethroids (beta-cyfluthrin, cypermethrin, deltamethrin, and lambda-cyhalothrin) accounted for 37.2 % and 29.0 % respectively (Figure 3-B). Non-chemical methods employed for control (Figure 3-C) comprised the filling of maize whorls

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with sand grains (22.2 %) or botanical ash (14.4 %), handpicking larvae off plants (20.9 %), intercropping maize with other crops (17.0 %), rouging and burning of infected plants (18.9 %) among others. The usually sudden damage observed on maize plants may have warranted the exclusive application of synthetic insecticides by many respondents in this study (Prasanna et al., 2018). The use of inappropriate insecticides, use of adulterated insecticides, incorrect insecticide application rates or techniques, and wrong timing of spray application might be responsible for the low insecticide effectiveness reported by most respondents (FAO, 2018; Kumela et al. 2018).

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Table 3: Knowledge and management of fall armyworm amongst maize farmers

Variable		Percentage (n=195)
Fall Armyworm Knowledge		
i.	**Fall armyworm attacking maize looks like**	
	small green grasshopper	5.1
	small brown butterfly	19
	small crawling worm	75.9
ii.	**Fall armyworm and not stem borer larvae**	
	Color is different	18.9
	Size is different	19.3
	Eating pattern is different	33.9
	Fecal excretion on maize leaves	23.3
	Cannot tell the difference	4.7
iii	**Main source of information on fall armyworm**	
	Farmers	40.9
	Extension agents	50.5
	Media	8.6
Fall Armyworm Management		
i	**Management strategies**	
	Insecticide spray	58.5
	Non-chemical method	6.7
	Both insecticide spray and non-chemical method	31.8
	No control applied	3.1
ii	**Number of times insecticide was sprayed**	
	1 - 2 times	71.6
	3 - 4 times	22.2
	5 - 6 times	5.7
	7 - 10 times	0.6
iii	**Effectiveness of insecticide sprayed**	
	Excellent	32.4
	Moderate	57.4
	Poor	10.2

Source: Field Survey, 2018

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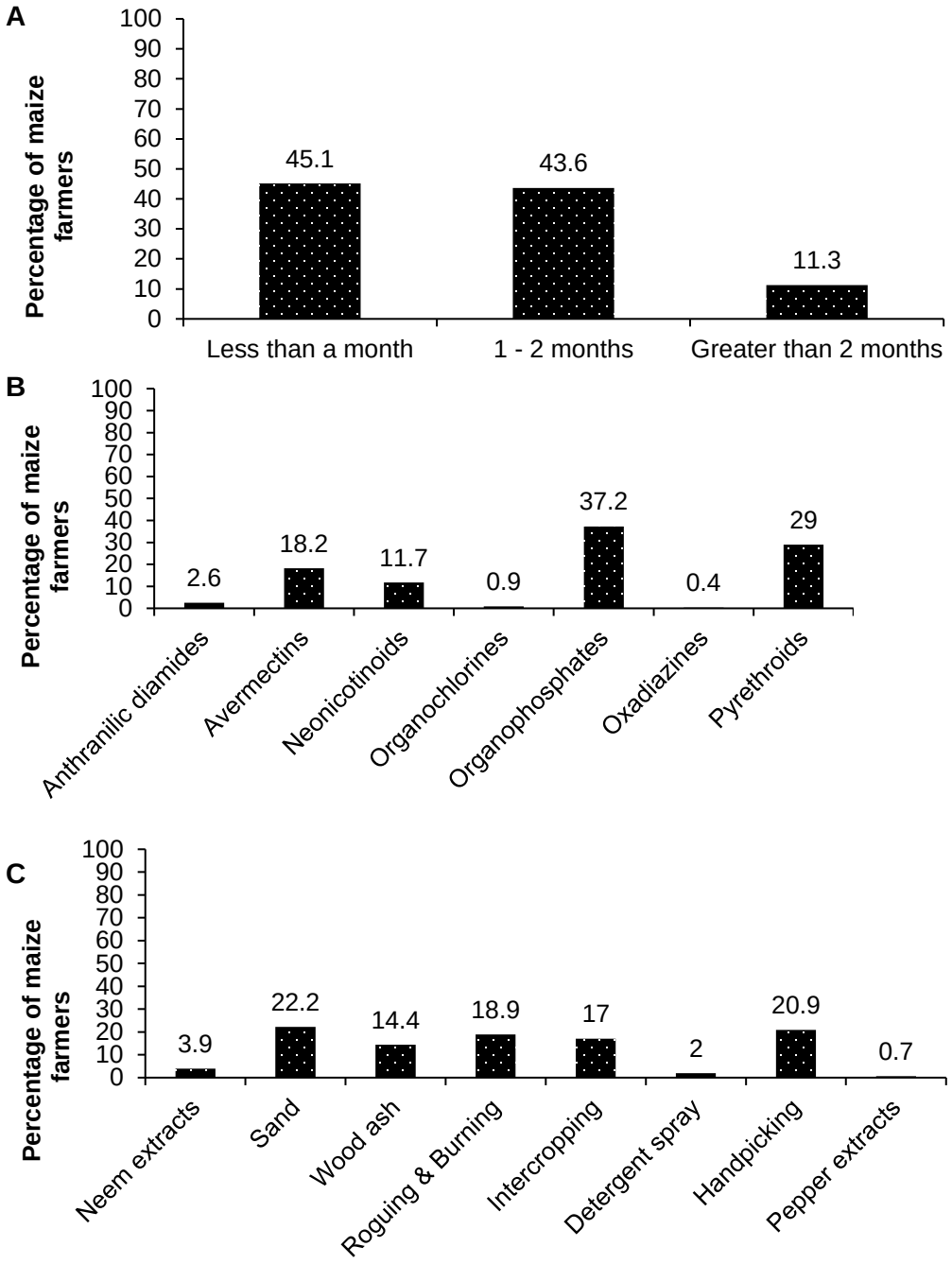

Figure 3: (A) age of maize attacked by fall armyworm; (B) synthetic insecticides sprayed for fall armyworm control; (C) non chemical methods used for fall armyworm control

Farmers' Perception of Damage to Maize by Fall Armyworm

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Farmers' perception of fall armyworm damage (Table 4) as a serious and worrisome problem was very high (4.82) in the present study. Also, their perception of the negative impact of maize damage by the insect pest on harvest (4.67) and profit (4.67) was equally very high. Respondents' had a high perception (3.50) of fall armyworm damage severity to early season maize as opposed to late season maize. On the other hand, maize farmers' perception of the pest's severity of damage to intercropped maize (2.92) as opposed to sole maize was moderate. Similarly, respondents had moderate perception (3.11) of the level of education available on fall armyworm damage to maize in the study area. The hypothesis that farmer's perception of fall armyworm damage to maize is associated with agroecological zone was tested and strongly supported ($\chi^2 = 77.2$) in this study. Perception of maize farmers about fall armyworm damage is, to some extent, consistent with previous reports obtained using socio-economic surveys and farmers estimates (Kumela et al., 2018; Kansiime et al., 2019). Baudron et al. (2019), however, used field scouting and quadrant harvesting methods and found that the impact of fall armyworm damage on maize yield was about nine percent and thus much lower than estimates obtained from socio-economic surveys and farmers reports.

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Table 4: Perception of maize damage by fall armyworm amongst maize farmers

Perception Statements	Mean	Standard Deviation
Maize damage by the fall armyworm is a problem to be worried about	4.82	0.40
Fall armyworm damage reduces quantity of maize harvested	4.67	0.63
Fall armyworm decreases profit of maize production	4.67	0.72
Damage by fall armyworm is more severe in early maize than in late maize	3.50	1.25
Damage is more severe on maize when intercropped than when planted as sole	2.92	1.11
Sufficient education is available to maize farmers on fall armyworm damage	3.11	1.39
Overall Mean	**3.94**	**0.87**

Source: Field Survey, 2018

Conclusions and Recommendations

Agroecological zone and maize plant age appear to influence the severity of damage reported by farmers in the present study. Synthetic insecticides were primarily used for control but with mostly moderate effectiveness reported. Periodic field scouting is recommended for effective management of fall armyworm but farmers would require training to correctly identify all stages of the pest. Exclusive insecticide application should be discouraged to prevent resistance development in fall armyworm populations in the study area. Integrated pest management approach is a sustainable alternative to the sole use of insecticides and should be promoted. However, when absolutely necessary to apply conventional insecticides, farmers should endeavour to spray directly into maize funnels early or late in the day for optimal effectiveness.

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OOA (45%) Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing of original draft, Draft review & editing. 45% Contribution
OAA (35%) Conceptualization, Methodology, Project administration, Supervision, Validation, Visualization, Draft review & editing. 35% Contribution
TKA (15%) Methodology, Validation, Draft review & editing. 20% Contribution

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