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EFFECTIVENESS OF PITFALL TRAP COLORS IN MONITORING ADULTS OF BLISTER BEETLE *MELOE PROSCARABAEUS* LINNAEUS, 1758 (COLEOPTERA: MELOIDAE) IN FABA BEAN FIELDS AT EL-FARAFRA OASIS EGYPT

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ABSTRACT

The blister beetles *Meloe proscarabaeus* Linnaeus, 1758 (Coleoptera: Meloidae), is a dangerous pest that threatens the agriculture of faba bean fields in El-Farafra Oasis, New Valley Governorate. In this study, an evaluation of the efficiency of different pit-fall trap colors for capturing adults of the blister beetles has been performed in faba bean (*Vicia faba* L.) fields. The experiment revealed that the green and red traps showed the highest number of captured beetles during the 2020 and 2021 seasons, which was highly significant to other traps' colors. On the other hand, black, blue, gray, white, and yellow traps showed insignificant differences in the number of captured beetles. Concerning the sex of trapped beetles; it could be highlighted that the green trap attracted more female beetles than males with significant differences. Inversely, the red color trap attracted more males than females with significant differences. Approximately 40% of the captured beetle population was recorded in March, while only 11% were trapped in April. A Green pit-fall trap could be deemed a new estimating assay to suppress *M. proscarabaeus* adults in faba bean fields since the color trap variation affected the number of captured beetles. Therefore, color traps can be relied upon as an effective method in controlling beetles without the number of beetles reaching the limit of economic damage and in a manner that is safe for the environment.

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INTRODUCTION

There are more than 2,500 species of blister beetles in the family Meloidae (Coleoptera), which are divided into 120 genera and three subfamilies (Akbar et al., 2017). El-Sheikh and Tokhy (2020) reported the first detection of the adult blister beetle *Meloe proscarabaeus* Linnaeus, 1758 (Coleoptera: Meloidae) as a phytophagous insect feeding on legumes in the New Valley governorate (El-Farafra oasis) in 2016. Since that time, its population showed considerable outbreaks, especially, in the newly reclaimed areas. Although, Alfieri (1976) recorded this insect as a collecting species of desert fauna in the vicinity of Cairo, where no information is available about its biology, ecology, and host relationships. Different species of blister beetles have been recorded in different parts of the world as serious pests of alfalfa, faba bean, wheat, and peanut (El-Sheikh and El Kenway, 2020; El-Sheikh, 2020). Pitfall traps, which were first defined by Barber (1931), are very regularly utilized for testing in terrestrial ecology. Pitfall traps are useful for examining the distribution and relative abundance of ground-dwelling arthropods, such as spiders and carabid beetles

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(Coleoptera: Carabidae). Generally, pitfall traps encompass boxes that might be inserted flush with the floor and packed with a fluid, which maintains and kill any animals dwindling into the traps. This auto-sampling approach is time-effectual, smooth to utilize, low-cost, and effects catch wealth in each species and individual (Buchholz et al., 2010). It has long been recognized that color is a vital factor in the retort and attraction of several insect species. Richmond and Metzger (1929) reported that traps tinted green were additional appealing to the Japanese beetle, *Popillia japonica* Newman than uncolored traps. Blue traps were utilized for the gathering of Apple Blossom Beetle, *Epicometis hirta* Poda (Aydın, 2011), and *Tropinota squalida* Scop. The color sensitivity and attraction of insects have been used by many researchers to collect insects and study population dynamics and swarm activity (Moericke, 1950; Hesler and Sutter, 1993; Laska et al., 1986; Streinzer et al., 1986; Zehnder and Spees, 1987). Sufficient forecasting assays and population dynamics investigations are required for the start of an effective control assay and experiments on the economic aspects of control. Sadly, earlier research on the harmful beetle *Melo proscarabaeus* has not revealed any information about such methods in Egypt. Thus, we aimed at initiating to elucidate the influence of several colors on *M. proscarabaeus* beetles' attractancy under normal circumstances of faba bean fields.

MATERIALS AND METHODS

Study area and sampling design

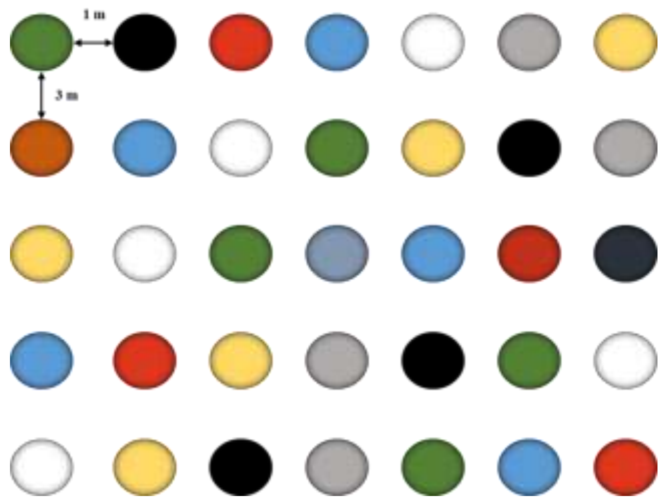
The current study was done in the El-Kefah locality (27°03′30″N 27°58′12″E) at El-Farafra oasis, Egypt. The field experiments commenced in January and continued till the end of April 2020 and 2021 of faba bean growing seasons and the period through which the populace activity of *M. proscarabaeus* adults maximized (El-Sheikh and El Kenway, 2020).

Experimental design

In these experiments, the influence of pit-fall traps painted with conventional colors was examined on the trap's attractancy to the insect adults. Meanwhile, 35 plastic plates, 50 cm dia., and 20 cm depth, each colored green, black, red, blue, white, gray, and yellow (5 dishes per color) were investigated. Dishes were supplied with vapona (insect-killing material) and operated in a faba bean field of approximately 2 hectares.

Traps were dug in the field ground and circulated in a randomized complete block design, where the repeats within blocks comprised the singular traps. Traps were in the field with 1 meter among traps in the block and 3 meters among the blocks. Traps were inspected every 3 days and trapped beetles were collected and discarded.

Arrangement of the differently colored pitfall traps site (35 traps, 7 rows, and 5 columns. (G) Green, (B) Black, (R) Red, (BL) Blue, (W) White, (G) Gray, and (Y) Yellow.



Analysis

The observed parameters in the study were the average of beetles trapped and their sex ratio. The average of beetles was obtained by counting the number of beetles in each treatment and repetition. *M. proscarabaeus* sex ratio was obtained by looking at the gender of *M. proscarabaeus*. After that, the amount of each gender of beetle was recorded and calculated.

Statistical Analysis

Analysis of variance (ANOVA) via Fisher Least Significance Difference assay to decline the null hypnosis and verify the existence of significant differences among several morphometric measurements was used. The analysis was available using Sigma Plot ver., 12.5 and Minitab ver., 18.1 software. The Pearson Chi-square test for association was available using Minitab ver., 18.1, software.

RESULTS

Based on the obtained results, the green traps were the most efficient for trapping adults of the blister beetle, *M. proscarabeus* in the field followed by red ones. Although green and red colors attracted a great number of beetles sex as shown in Table 1, where the green color attracted 591 adult females while 531 male adults were captured by red color, other colors bore insignificant differences among several females and males. Thus, the green color attracted the greatest number of *M. proscarabaeus* females while the opposite trend was shown by male beetles in a red color trap.

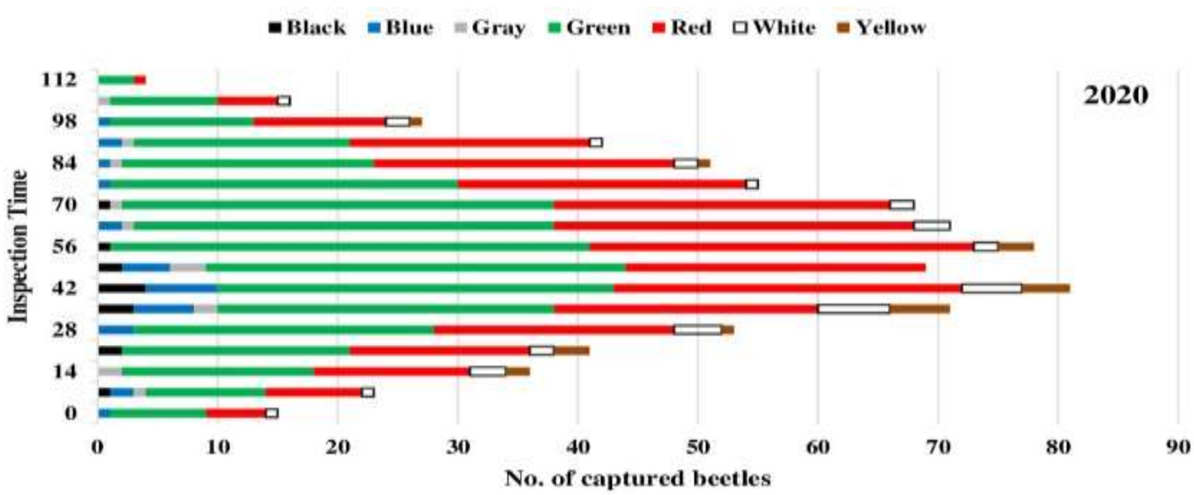
Table 1. Pearson Chi-square test for the association for both male and female captured beetles in seasons 2020 and 2021.

Trap color		2020 season			2021 season		
		Female	Male	Total	Female	Male	Total
Black	Obs.	8	6	14	9	7	16
	Exp.	7.13	6.87		8.05	7.95	
Blue	Obs.	17	11	28	8	4	12
	Exp.	14.26	13.74		6.04	5.96	
Gray	Obs.	5	8	13	4	6	10
	Exp.	6.62	6.38		5.03	4.97	
Green	Obs.	327	50	377	264	34	298
	Exp.	192.03	184.97		149.92	148.08	
Red	Obs.	27	286	313	22	245	267
	Exp.	159.43	153.57		134.32	132.68	
White	Obs.	17	19	36	11	16	27
	Exp.	18.34	17.66		13.58	13.42	
Yellow	Obs.	7	13	20	8	10	18
	Exp.	10.19	9.81		9.06	8.94	
Total		408	393	801	326	322	648

Obs. Observation; Exp. Expected

Altogether, pitfall trapping yielded 1455 beetles. The color preference of *M. proscarabaeus* adults was indicated by the number of captured insects in different color traps, Overall catches decreased from Red < Green < White < Blue < Yellow < Gray < Black (Figure 1). It was revealed that the green and red traps showed the highest number of captured beetles (337.5 and 290) during the 2020 and 2021 seasons respectively. There was a significant difference between colors in the sums of captured beetles in 2020 and 2021 (*f=3.213, p<0.001*) (*f=51.543, p<0.001*), respectively.

Differences among numbers caught in the Green and Red color traps were significant, green color values were significant compared with the other traps' color for gray (*t=12.2, p<0.001*) (*t=11.2, p*<0.001), black (*t=12.2, p<0.001*) (*t=10.9, p<0.001*), yellow (*t=12.0, p<0.001*) (*t=10.9, p<0.001*), blue (*t=11.7, p<0.001*) (*t=11.1, p<0.001*) as well as white (*t=11.5, p<0.001*) (*t=10.5, p<0.001*).



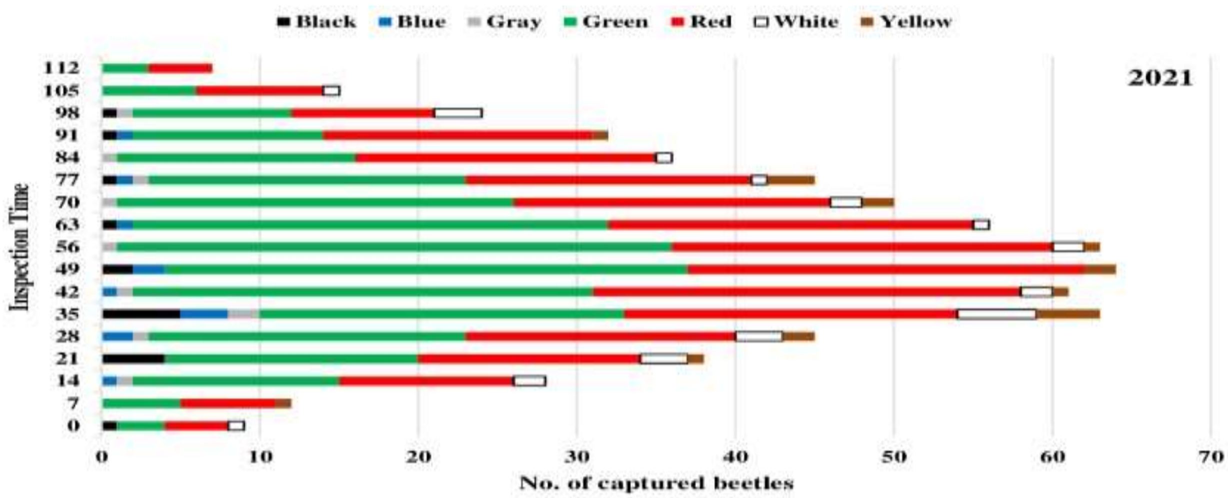


Figure 1. Clustered bar line chart showing the observed count numbers of captured beetles during the inspection time of the experimental period within 2020 and 2021 season.

In the same manner, the red color trap was also highly significant compared with the other color traps with values for gray (t=10.1, p<0.001) (t=10.0, p<0.001), black (t=10.0, p<0.001) (t=9.7, p<0.001), yellow (t=9.8, p<0.001) (t=9.7, p<0.001), blue (t=9.6, p<0.001) (t=9.9, p<0.001) as well as white (t=9.3, p<0.001) (t=9.4, p<0.001) during 2020 and 2021 seasons respectively. On the other hand, black, blue, gray, white, and yellow traps showed insignificant differences ($P>0.001$) in the number of captured beetles.

The probational male and female numbers in every trap color are summarized in Figure 2 and Table 1. Highlighting that the green trap attracted more female beetles than males with significant differences ($P<0.05$) Inversely, the red color trap attracted more males than females with significant differences ($P<0.05$) in 2020 and 2021 respectively.

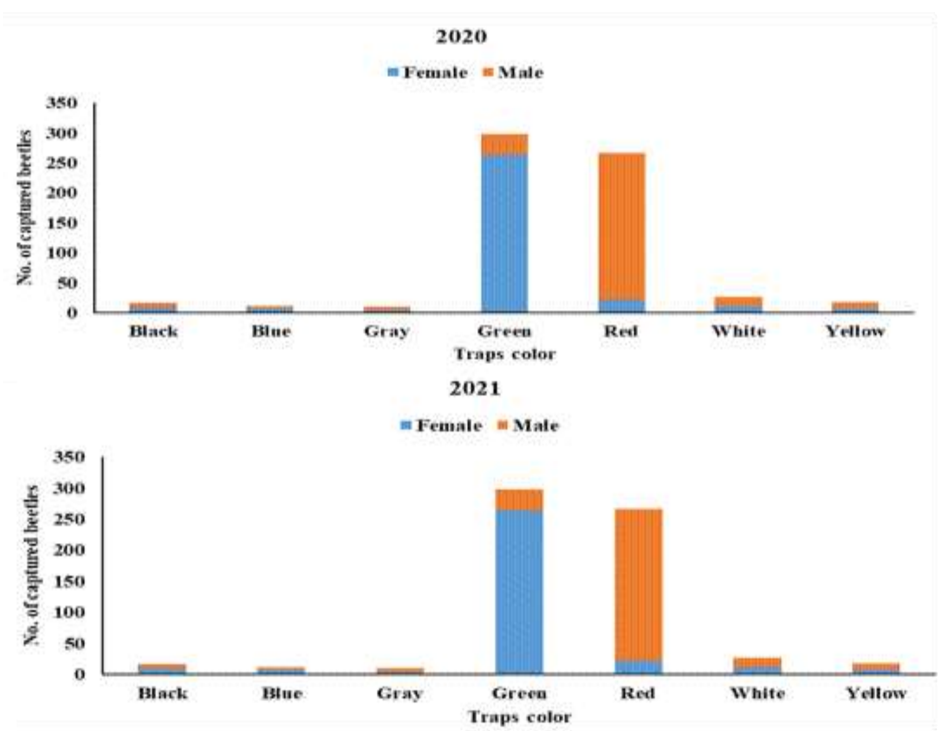


Figure 2. Stacked bar chart revealed the probation between captured male and female beetles using different trap colours during the experimental period within 2020 and 2021 seasons.

To better visualize the different color-graded inspection time (according to the count of captured beetles on each inspected day) on which the colored traps has been clustered. A two-way cluster (heat map) showed the similarities and the differentiation and organizes the investigated colored traps into one cluster, showing their close and far relation (Figure 3). Revealing that the green and red traps clustered on one side of the cluster while black, yellow, gray, blue, and white traps clustered on the other arm of the cluster. On the other hand, the inspection time is organized in a correlated relationship according to their contribution by counting captured beetles.

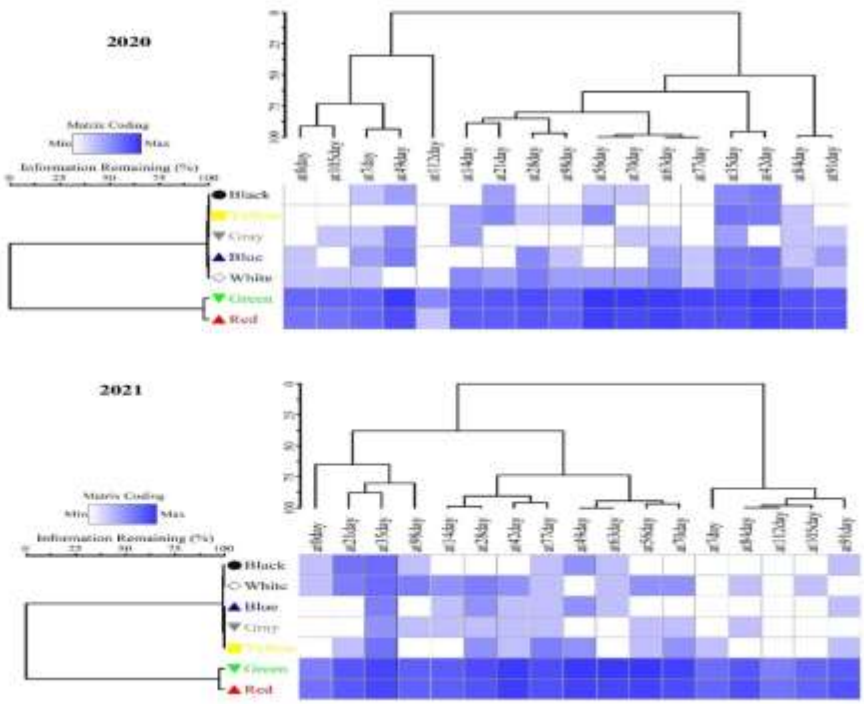


Figure 3. Two-way cluster (Heat map) shows colour graded inspection time according to the count of captured beetles for each trap colour during the experimental period in 2020 and 2021 season.

The PCA ordination graph-colored traps are represented as symbols (Figure 4), while inspection time is represented as arrows with direction toward its positive correlated trap within ordination, and the variable length revealed its' correlation value. This confirmed that the color trap variation affect the number of captured beetles. Regarding the attractancy values (Table 1), traps painted red ranked second-order, while the other colors attracted very low numbers. Thus, tested colors could be classified into the groups, colors of high attractancy 100 RA (green) groups of 73 RA (red color), and very low negligible attractancy groups of 4, 6, 3, 9, and 5 RA (black, blue, gray, white, and yellow colors).

DISCUSSION

Pitfall traps have been used more than any other approach to evaluate the arthropod plenty or biomass and the utilization of pitfall traps has amplified over time. Pitfall trap methodologies and designs differ significantly between studies, and their diverse applications have resulted in the successful identification of highly diverse insect communities (Skvarla et al., 2014).

Our results indicated that the color factor played a greater role in orientation and attracting insects in the environment to food, shelter, and oviposition. This phenomenon was incorporated with different trap devices for monitoring and estimating insect populations. From a biophysical point of view, color perception by insects depends on the type of photoreceptors in their visual system. The type of bait in a pitfall trap can directly affect which taxa are captured (Greenslade and Greenslade, 1971). Recently Strinzer et al. (2019)

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reported that color-trapping experiments showed a high preference for red color over the other colors in beetles. They suggested that a simple chromatic mechanism is sufficient to explain the insect's color choices.

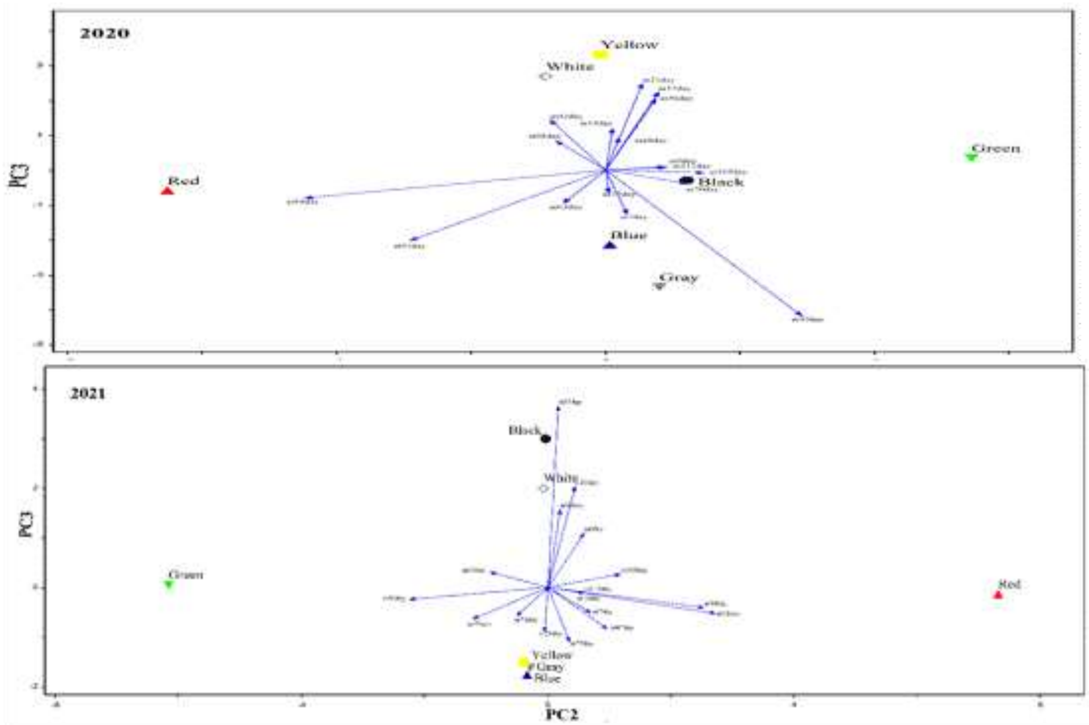

Figure 4. Principal component analysis (PCA) performed on trap characteristics (different colour) for *Meloe proscarabaeus.*

These results tied well with previous studies reported by Nakamoto and Kuba (2004) in the West Indian sweet potato weevil, *Euscepes postfasciatus* (Fairmaire). The partiality tests are done via 4 colors of LEDs (blue, green, yellow, and red) at mended gentle quanta in the laboratory. Meanwhile, weevils desired the green LED for the other three. The effectiveness of the green LED trap was then equated to the sweet potato root trap in a sweet potato field, and the green LED trap was verified to be suitable for observing *E. postfasciatus* of weevils. This outcome is contrary to the findings of Math (2017) who found that the yellow color trap attracted more fruit flies when baited with Methyl eugenol. However, the findings of the current study disagreed with the previous research reported by Ali (1993) who found that traps painted blue captured high numbers of *Tropinota squalida* beetles while red ones had no attraction effect. These findings also disagreed with our achieved results since the greatest numbers of the blister beetle adults were trapped in green pit-fall traps. Although yellow trap was noted as an effective tool for detaining several insect species (Ladd and Klien, 1983; Southwood, 2009), who confirmed that this color was inappropriate for the blister beetle adult. Results also suggested that any gray, black, blue, yellow, and white colors cannot be utilized in place of standard green or red, and the appropriateness of pit-fall traps as a novel assay for examining swarming dynamics and estimating *M. proscarabaeus* beetles. The finding is contrary to previous studies which have suggested that brown trap colors proved the most effective in the field to capture *R. obscurus*, followed by, in order, yellow, red, gray, blue, black, white, and green; russet was more actual than other hints of brown. In addition, the paint of the other colors with brown paint insignificantly enhanced its performance. Inversely, laboratory color-select tests noted that *R. obscurus* favoured the black traps over those of other colors and found no partialities among various shades of the black color (Reddy et al., 2018). This result ties well with previous studies wherein by Mohamed et al. (2012) who found that captures of *Rhynchophorus ferrugineus* in black traps were significantly higher than that in red, yellow, and/or white traps. The greatest weevil fastening was done in the red trap (Al-Saoud et al., 2010). Contrary to the findings of Buchholz et al. (2010) who implied that in open grassland habitats the key mutual arthropods of upkeep attention that are fixed by pitfall traps, carabid beetles, and spiders were utmost regularly gathered in white- and yellow-colored traps. Other results were broadly in line with Fezza et al. (2022) showed that vine weevil, *Otiorhynchus sulcatus* F. adults preferred the black color trap. More than blue, red, green, and yellow trap color in addition to black and white color trap disclosed a partiality for black and blue over the other colors and white resorts in group selection experiments. The results of the current study and related previous studies examined so far can be summarized as follows:

This study showed that there is a strong relationship between colors and the attraction of beetles. The efficiency of the green and red traps was more attractive than the rest of the colours. Therefore, it can depend on the green color to attract females and the red color to attract male beetles as an effective biotechnological method to control beetles without the pest density reaching the threshold of economic damage. Pesticide application against said beetles may not be needed with the correct trap selection at the right time. Thus non-target organisms such as honey bees, birds of prey, etc. will not be adversely affected when insecticides are used.

CONCLUSION

In conclusion, we proved that green pit-fall traps are the utmost efficient trap color for charming and detaining adults of *M. proscarabaeus* L. The virtual attractancy of the trap was noticeably manipulated by trap color phenology and micro-ecological conditions. Further studies are needed to find out whether this assay can be utilized in managing *M. proscarabaeus* adults when the population is low, in the study of insect swarming dynamics and the insect population in each area.

AUTHORS' CONTRIBUTIONS

AEK and WEAE conceptualized the study, acquired funding, conducted investigations, collected, arranged and analyzed the data, wrote the first draft, reviewed, edited and proofread the manuscript..

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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