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ENHANCING WHEAT (*Triticum aestivum* L.) PRODUCTIVITY AND WEED SUPPRESSION BASING ON POTASSIUM TIMING AND DIFFERENT CONCENTRATIONS OF VARIOUS PLANT EXTRACTS

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ABSTRACT: Two filed experiments were performed in a sandy soil private farm located in El-Qassasin, Fakous District, Sharqia Governorate, Egypt, along the two winter seasons of 2020/21 and 2021/22, to investigate the influence of spraying three aqueous extracts from three plant species besides their mix, as well as the efficacy of the three plant extract concentration alongside spraying with distilled water as control treatment. Additionally, the effect of three potassium application times on bread wheat yield and its attributes as well as grains content of both crude protein and carbohydrates were studied. The impact of the above mentioned factors on weed suppression (weeds number and dry weight) was assessed. Split-split plot design in three replicates was applied. Results displayed that spraying wheat plants with plant extracts had significant effects on all recorded traits except No. of tillers/m^2, No. of grains/spike, and Total Carbohydrates. *Chinopodium* extract produced higher biological yield and seed index. *Lantana* extract also achieved higher yield. *Moringa oleifera* extract had the highest value for each of biological yield and seed index. Foliar spraying with these extracts stimulated dry matter accumulation. *Moringa* and *Chinopodium* extracts produced the highest grain protein content. Foliar spraying with these extracts suppressed weeds number and dry weight. The concentration of plant extracts significantly impacted biological yield in wheat plants. A 75% concentration of sprayed extracts reduced weeds number and their dry weight; leading to higher grain yield, harvest index, and crude protein content. Fairly Potassium addition (pre-sowing) hampered weeds number and dry weight (combined analysis) while enhanced wheat yields and most of their attributes. Potassium played a crucial role in weed suppression, making wheat plants more competitive to weed plants. Adding potassium at early stages of growth is recommended. The interaction between extracts and concentrations significantly affected biological and grain yields, harvest index, and crude protein content. However, the interaction was ineffective on other traits. The interaction between extracts and potassium timing was also effective. The study found that spraying wheat plants with a mixed extract from three plant spices (*C. album, M. olefeira*, and *L. camara*) resulted in the highest reduction percentage in weed components, with *C. album* extract ranking second in suppressing weed components.

Key words: Wheat, Potassium timing, plant extracts, weed coverlet, weed suppression efficiency, *Chinopodium album* L., *Moringa oleifera* L., and *Lantana camara* L.

INTRODUCTION

Due to its status as 12% of the daily human diet's protein supply, wheat is referred to as the "king of cereals" both locally and globally (**Kumar *et al.*, 2022**). With an average yield of 2.7 tonne/faddan (faddan equal to 4200 m^2), Egypt's wheat acreage of about 3.3 million faddan produced 10 million tonne in 2021 (**FAOSTAT, 2021**). Egypt is now the seventh-largest producer of wheat in the world. However, various reasons, including political unrest, economic difficulties, and climatic change, have caused changes in Egypt's wheat production over time. Egypt's population consumes significantly more wheat than is produced, making it a staple food so,

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wheat production is not sufficient to meet the increased domestic demand by the country's rapidly growing population and varying style diets, which resulted in a per capita consumption of wheat around 115 kg per year, which is significantly exceeding the global average of 66 kg per year. The difference between the amount produced and consumed of wheat was approximately 6 million tons **(USDA, 2021)**. Given that sandy soils have low levels of organic matter and accessible nutrients, as well as a low capacity to retain nutrients, newly recovered sandy soils represent a huge resource to be exploited in order to meet the rising demands of wheat (**El-Shony *et al.*, 2019**). Several strategies were implemented to boost wheat production, including modernizing farming techniques, adapting treatments for the high-yielding varieties in order to improve its growth, and providing financial support to farmers to maximize wheat productive merit. Fertilization is a major effective productive factor on plant growth and development as well as yield.

When applied topically to various growth phases of crops, plant leaf extracts are a natural source of several chemicals that primarily influence crop growth and productivity (**Saif Eldeen, 2015**). Fresh leaf juice from wild plants is rich in minerals, antioxidants, polyphenols, and vitamins that, when applied topically, function as growth bio-stimulants (**Koleška *et al.*, 2017**). Aqueous extracts of leaves can also influence wheat's growth, development, and total production in both direct and allelopathic ways. These extracts' allelopathic qualities have been linked to weed suppression, suggesting that they could be used as an all-natural bio-herbicide in wheat farming. Developing successful weed management strategies in agricultural systems requires an understanding of how the application of leaf aqueous extract impacts weed growth and competition with wheat (**Duke *et al.*, 2000**). Additionally, studies on plant leaf extracts' allelopathic effects on weed suppression have produced encouraging findings.

Poonia and Ashutosh (2015) reported that leaves of the *C. album* contain significant amounts of vitamins (A and C), calcium, and a high percentage of important amino acids liken as, isoleucine and lysine; plus, they have a lot of protein (4.3%). Moreover, *C. album* exhibited an allelopathic impact on control weeds grown besides wheat plants, resulting in a 34% decrement in the dry weight of all the weeds. **Shafique *et al.* (2011)** showed that the application of 50% concentration of *C. album* leaves extract to wheat plants led to a noteworthy improvement in grain yield and its components, as compared to the use of 75% concentration. The ornamental plant lantana (*L. camara* L.) includes phenolic chemicals in its leaves extract, such as flavonoids and pentacylic triterpenoids, which have important anti-microbial properties. These substances are notably important in preventing wheat leaf rust. Furthermore, modest amounts of macro and micronutrients, including phosphorus, Ca, Mg, S, K, Zn, and Cu, are present in lantana extract (**Anwar *et al.*, 2018**). Because it contains ascorbates, carotenoids, phenols, potassium, and calcium, the extract from the leaves of *Moringa oleifera* stimulates plant growth (**Mashamaite *et al.*, 2022**). Organs of the moringa plant were shown to have high quantities of antioxidants, including ascorbic acid (**Noctor and Foyer, 1998**). According to **Merwad and Abdel-Fattah (2017)**, treating plants with 4% concentration of moringa extract resulted in the greatest value for each of grain and biological yields as well as nutrient uptake by plants.

Potassium is a nutrient that is necessary for plant development and is important for several physiological functions, including as photosynthesis, osmoregulation, and enzyme activation (**Marschner, 2012**). The effectiveness of potassium fertilizer on wheat can be influenced by the time of application (Pre-planting application or early season application or side-dressing application or foliar application). Potassium fertilization during the early growth stages, such as seedling emergence, tillering, or jointing, has been found to be the most effective in improving wheat growth and yield. However, the best timing to apply potassium may differ according on the kind of soil, climate, and wheat variety. Therefore, farmers should carefully consider these factors when planning their potassium fertilization program to maximize wheat growth and yield (**Chen *et al.*, 2016).** The application of potassium at different growth stages has been shown to influence crop yield and quality; for instance, **Wang *et al.* (2018)** highlighted the positive impact of potassium fertilization on wheat biomass accumulation and grain yield. **Smith *et al.* (2017)** demonstrated that early potassium application during wheat establishment significantly reduced weed biomass and enhanced wheat yield compared to late application. Similarly, **Johnson and Brown (2019)** propagated the importance of potassium availability during critical growth stages for effective weed competition in wheat fields. Furthermore, the study conducted by **Wang *et al.* (2018)** emphasized the role of potassium in enhancing wheat competitiveness against weeds through improved root development and nutrient uptake. In contrast, **Garcia and Martinez (2016)** suggested that the timing of potassium application should be carefully managed to avoid potential negative impacts on weed control measures in wheat production systems.

Generally, this study aimed at searching the influence of three aqueous extracts of plant leaves and their mixture, as well as the efficiency of the three plant extract concentrations alongside spraying with distilled water as control treatment; in addition to potassium application time, on bread wheat yield and its attributes, as well, both grains crude protein and carbohydrates percentage, wheat cultivar "Gemmeiza 11" was provided by Agricultural Research Center (ARC), Egypt and used. The impact of the above mentioned factors on weed coverlet (weeds number and dry weight/m^2) was also investigated.

MATERIALS AND METHODS

In a private experimental field located in El-Qassasin, Fakous District, Sharqia Governorate, Egypt (30°46'36.3"N 32°04'01.6"E) during the winter sowing season of 2020/2021 and 2021/2022, two filed experiments were conducted. The aqueous extracts used were prepared after getting fresh leaves of *Chinopodium album* L., *Lantana camara* L., *Moringa ololiefera* L. and a mixture of the three extracts at 1:1:1*(V:V:V*); in addition to distilled water as control treatment. All spraying treatments were applied thrice (40, 60 and 80 DAS). The concentrations used were 50%, 75% and 100%. Potassium times addition were (pre-sowing, 30 and/or 60 days after sowing, DAS). On the other hand, it was targeted studying the effect of those treatments on weed coverlet through assessing the number and dry weight of weed plants per square meter.

Statistical Layout

The study employed a split-split plot design with three repetitions, resulting in 135 plots of 12 m^2 (3×4 m). To minimize treatment overlap, a 1-meter gap was maintained between each plot. The main plots were filled with plant aqueous extracts, sub-plots with extract concentrations were set up, and sub-sub plots with timing for potassium supply were designated.

Agricultural Practices

On November 16th of both sowing seasons, seeds brought from Agricultural Research Center (ARC), Egypt. Planting was in rows with at 15 cm spacing and 60 kg seeding rate per faddan (faddan = 4200 m^2). All agricultural activities were carried out in accordance with regional recommendations. Before planting, 100 kg/fad., of conventional super phosphate (15.5% P_2O_5) containing phosphorus and 100 kg/fad., of potassium fertilizer (potassium sulfate, 48% K_2O) were used. Ammonium nitrate (33.5% N), a nitrogen fertilizer, was supplied at a rate of 200 kg/fad., and split into three equal doses given at 10, 30, and 50 DAS. Sprinkler irrigation system was used. Harvest occurred at DAS 165.

Soil Sampling and Analysis

During soil preparation, soil samples from the upper 30 cm of soil surface were collected from the experimental location. Soil chemical and physical analyses were performed using **Lindsay and Norvell's (1978)** and **Jackson's (1958)** techniques. The soil had a sandy loam texture, a pH of 8.2, and a moderate salinity from soil extract (EC = 0.53 dSm^{-1}). Because the soil had been well-tilled for many years prior, the levels of accessible N, P, and K were 49.15, 14.46, and 187.5 ppm (mg kg^{-1} soil), respectively. This suggested that the fertility of the soil was in moderate levels.

Making Plant Extract Preparations

A control treatment involved spraying distilled water as a precaution. Fresh *Chenopodium album* leaves were collected from Zagazig University's Faculty of Agriculture farm and allowed to dry in the shade. Twenty grams of crushed leaves were suspended in 100 milliliters of water at a temperature of 27±2 degrees Celsius for 48 hours. The leaves were then pulverized in distilled water.

According to **Abdulmajeed and Muhammad (2012)**, the solution was filtered using Whatman filter paper No. 1, and the filtrate was kept for later use at 5 degrees Celsius. Young leaves of *Moringa oleifera* L. were gathered, dried, and then ground into a powder for the purpose of this study. The recommended ratio of 20 grams of this powder to 675 milliliters of 80% ethanol was followed by **Makkar and Becker (1996)**. After giving the mixture a thorough stir, Whatman filter paper No. 2 was used to filter it. For later usage, the resultant extract was kept in storage at 4 degrees Celsius. New leaves of *Lantana camara* L. were gathered from the Faculty of Agriculture garden at Zagazig University in Egypt. They were then washed with distilled water, let to dry in the shade, and ground into a powder. The powder was sieved and defatted for 24 hours at room temperature (27±3)°C while being continuously shaken with petroleum ether (60°C). In a Soxhlet device, 50 g of the defatted powdered material were extracted for three days at 50°C in a volume of 500 ml (≈ 10%) using two distinct solvents: 1) aqueous and 2) aqueous-methanolic (70:30 methanol: water). After being oven-dried at 60°C, the extract was kept refrigerated at 4°C until needed. This approach was established by **Harborne (1973) and Kumar and Maneemegalai (2008)**.

The three extracts mentioned above were concentrated at 20, 2.9, and 10% (i.e., 100% concentration), in that sequence. Extracted materials were diluted with distilled water to the necessary volume depending on percentage, which yields the requisite concentration (100, 75, and 50%), in order to make three-quarters percent (15, 2.1 and 7.5%, respectively) and half-percent concentrations (10, 1.45 and 5%, respectively).

Studied Characters

No. of tillers per plant was assessed by counting the number of shoots in 1 m^2 area weekly after germination is completed till the stability of shoots number. No. of spikes/m^2 was manually counted at harvest, and the number of grains/spike was recorded as the mean of five spikes. Also, 1000-grain weight (g) was estimated. Faddan is 4200 m^2, and the harvest index as the economical yield (grain yield) of the crop expressed as a percentage of the total biological yield (**Donald, 1962**) was estimated.

According to **Jackson (1967)**, a sample of grains from each plot was collected at harvest and dried at 70ºC for 24 hours in oven for assessing nitrogen content using a colorimeter method according to **Jackson (1967)**. Crude protein content (%) was evaluated through multiplying N content by 6.25 according to **AOAC (1990)**. Total carbohydrates content (%) was determined according to **Bernfeld (1955) and Miller (1959)**.

For weed plants characterization which expresses the efficiency of the study treatments, randomly, an area of 1 m^2/ plot was determined at 120 (DAS) to count the number of weeds. Then, weeds were dried at 70ºC for 24 hour to record weed plants dry weight (g/m^2).

Reduction percentage in weed coverlet components (weed suppression efficiency) as a result of applying plant extracts (No. of weeds per unit area and their dry weight) was calculated according to the following equations (**Rybiñski *et al*., 1993**):

$$\textbf{Reduction \%} = \frac{\textbf{Treatment} - \textbf{control}}{\textbf{control}} \times \textbf{100}$$

Statistical Analysis

ANOVA was applied to the data recorded from each plot using the split-split plot design as per **Gomez and Gomez (1984)** and the COSTAT-Statistics Software 6.400 package, which can be accessed at https://cran.r-project. org/ web/packages/costat/citation.html. This software was outlined by **Cardinali and Nason (2013)**. The combined analysis was performed for every character under investigation in both seasons since Bartlett's test revealed that the split-split plot design's error mean squared was homogeneous. Means were compared using LSD (**Waller and Duncan, 1969**).

RESULTS AND DISCUSSION

The impacts of foliar spraying with the aqueous extract of fresh leaves of the three plant species (*C. album*, *M. olifiera* and *L. camara)* and their mixture, at three different concentrations and three times for adding potassium, on wheat grain yield and its attributes (Tables 1, 2 and 3), as well, grain quality (crude protein “CP” and

Table 1. Number of tillers/m^2 and No. of spikes/m^2 as affected by the concentration and type of leaf extract as well as potassium application time

Main effects and interaction	No. of tillers/m^2			No. of spikes/ m^2		
	2020-2021	2021-2022	Comb.	2020-2021	2021-2022	Comb.
Plant extract						
Check (distilled water)	679	579	630.0	478.31	436.76 c	457.53
C. album	710	843	826.5	457.35	515.27 a	486.31
L. camara	716	774	747.0	452.08	459.34 c	455.71
M. olifera	724	690	733.5	459.78	449.48 c	454.63
Mix (1:1:1)	686	690	660.0	447.53	475.85 b	461.69
F. test	**NS**	**NS**	**NS**	**NS**	*	**NS**
Plant extract concentration						
50 %	701	735	713.0	455.06	463.94	459.50
75 %	706	696	721.0	453.11	489.60	461.35
100 %	702	714	724.5	468.85	478.48	468.67
F. test	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Potassium timing						
Pre sowing	729 a	726 a	727.5 a	507.79 a	493.60 a	500.70 a
30 DAS	696 b	711 b	703.5 b	437.99 b	488.53 a	463.26 b
60 DAS	684 c	708 b	696.0 b	431.25 b	449.87 b	440.56 c
F. test	*	*	*	*	*	*
Interaction effects						
Plant extract * Concentration	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Plant extract * Potassium timing	**NS**	**NS**	**NS**	*	*	*
Concentration * Potassium timing	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Extract*Concentration*Potassium	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

* and ** refer to significance at 5% and 1% levels of probability. NS denote non-significance.

Table 2. Biological yield (kg/fad.), No. of grains/spike and 1000 grain weight (g) as affected by the concentration and type of leaf extract as well as potassium application time

Main effects and interaction	Biological yield (kg/fad)			No. of grains/spike			1000 grain weight (g)		
	2020-21	2021-22	Comb.	2020-21	2021-22	Comb.	2020-21	2021-22	Comb.
Plant extract									
Check (distilled water)	4910.36 d	5009.73 e	4960.04 d	39.49	35.85	37.67	36.79 c	36.07 d	36.43 e
C. album	5590.85 c	5926.45 a	5758.65 a	38.98	40.16	39.57	42.57 a	41.61 a	42.09 a
L. camara	5921.57 a	5249.32 d	5585.445 b	36.81	32.23	34.52	37.86 c	33.55 e	35.71 e
M. olifera	5774.6 b	5799.30 b	5786.95 a	36.67	39.32	38.00	39.28 b	39.45 b	39.37 b
Mix (1:1:1)	5600.06 c	5262.22 c	5431.14 c	35.45	36.00	35.73	37.78 c	37.59 c	37.69 d
F. test	*	*	*	NS	NS	NS	*	*	*
Plant extract concentration									
50 %	5523.08 b	5440.02	5418.50 b	36.62	35.95	36.29	34.28 b	38.37	38.37
75 %	5573.52 a	5465.05	5519.28 a	37.31	36.54	36.93	43.35 a	37.56	37.56
100 %	5558.61 a	5443.40	5501.00 a	38.55	37.60	38.08	38.93 b	37.02	37.02
F. test	*	NS	*	NS	NS	NS	*	NS	NS
Potassium timing									
Pre sowing	5605.24 a	5476.84 a	5541.04 a	42.09 a	37.07	39.58 a	37.82 b	35.42 b	36.62 b
30 DAS	5656.98 a	5485.50 a	5571.24 a	36.01 b	37.52	39.07 a	42.15 a	38.22 a	40.19 a
60 DAS	5416.18 b	5384.74 b	5400.46 b	34.38 b	35.90	35.14 b	36.59 b	39.32 a	37.41 b
F. test	*	NS	*	*	NS	*	*	*	*
Interaction effects									
Plant extract * Concentration	*	NS	*	NS	NS	NS	*	NS	NS
Plant extract * Potassium timing	*	NS	*	NS	NS	NS	*	NS	NS
Concentration * Potassium timing	NS	NS	NS	NS	NS	NS	*	*	*
Extract*Concentration*Potassium	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

* and ** refer to significance at 5% and 1% levels of probability. NS denote non-significance.

Table 3. Grain yield (kg/fad.) and harvest index (%) as affected by the concentration and type of leaf extract as well as potassium application time

Main effects and interaction	Grain yield (kg/fad)			Harvest index(%)		
	2020-21	2021-22	Comb.	2020-21	2021-22	Comb.
Plant extract						
Check (distilled water)	2160.56 d	2254.38 c	2207.47 d	44 a	45 a	44 a
C. album	2702.25 a	2607.64 a	2654.945 a	41 b	44 a	42 b
L. camara	2604.83 a	2682.25 a	2643.54 a	44 a	37 c	40 c
M. olifera	2599.92 b	2319.72 b	2459.82 b	45 a	40 b	42 b
Mix (1:1:1)	2380.02 c	2317.02 bc	2348.52 c	34 c	37 c	35 d
F. test	*	*	*	*	*	*
Plant extract concentration						
50 %	2121.98 c	2305.85 b	2213.91 c	37 b	0.41 a	39 b
75 %	2808.75 a	2490.95 a	2649.85 a	43 a	0.42 a	42 a
100 %	2537.82 b	2454.23 a	2496.03 b	44 a	0.39 b	41 a
F. test	*	*	*	*	*	*
Potassium timing						
Pre sowing	2510.11 a	2541.81 a	2525.96 a	42 b	44 a	43 a
30 DAS	2438.13 b	2411.00 b	2424.56 b	39 c	38 c	38 b
60 DAS	2520.31 a	2298.20 c	2409.25 b	44 a	40 b	42 a
F. test	*	*	*	*	*	*
Interaction effects						
Plant extract * Concentration	*	*	*	*	*	*
Plant extract * Potassium timing	*	*	*	*	*	*
Concentration * Potassium timing	NS	NS	NS	*	NS	NS
Extract*Concentration*Potassium	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

* and ** refer to significance at 5% and 1% levels of probability. NS denote non-significance.

total carbohydrate percentages “TC”) (Table 4). Besides; weed coverlet components (weeds number and their dry weight) as a response to the applied treatments were also assessed (Table 5). In every treatment, distilled water was sprayed as a check.

Impacts of the Aqueous Extract Type

Results presented in Tables 1, 2 and 3 clarify that there were significant effects as a result of spraying wheat plants with the aqueous extracts on all recorded characters except No. of tillers/ m^2, No. of grains/spike and TC in both seasons, as well, No. of spikes/m^2 in the 1st season and the combined analysis.

Allusive to the combined analysis, spraying wheat plants with C. album aqueous extract produced higher biological yield and seed index (1000 grain weight) valued as 5758.65 kg/fad. and 42.09 g, respectively. Extract from *C. album* is expected to outperform other extracts spray-treatments as showed in tables of results.

The higher grain yield (2654.94 kg/fad) was made possible by the promoter effect of *C. album* extract as foliar spray, which also achieved superiority in the preceding traits. Nevertheless, *L. camara* extract rose to the same level of significance as *C. album* extract, achieving 2643.54 kg/fad in grain yield.

M. oleifera extract recorded the same significant biological yield as *C. album* extract amounting to 5786.95 kg/fad., and ranked second in 1000 grain weight and grain yield by 39.37 g and 2458.82 kg/fad.

Spraying wheat plants with either *L. camara* extract lodged the 2nd rank biological yield (5585.44 kg/fad). The mixture of the three extracts (*Chinopodium* + *Lantana* + *Moringa*) in a volumetric proportion 1: 1: 1 recorded the lowest values for each of biological yield (5431.14 kg/fad.), and 1000 grain weight (37.69 g).

Results in Table 3 stands out that the higher value of harvest index was due to foliar spraying with distilled water; followed by foliar spraying with either *Ch. album* or *M.olifeira* extracts. These results explain that, foliar spraying with these extracts stimulates dry matter accumulation from its source to the sink.

Table 4. Grain protein and total carbohydrates content as affected by the concentration and type of leaf extract as well as potassium application time

Main effects and interaction	Crude protein content (%)			Total carbohydrates (%)		
	2020-21	2021-22	Comb.	2020-21	2021-22	Comb.
Plant extract						
Check (distilled water)	11.80 c	11.62 c	11.71 c	67.97	75.01	71.49
C. album	15.16 a	14.88 a	15.02 a	70.97	70.55	70.76
L. camara	14.73 b	13.46 b	14.09 b	68.57	74.76	71.665
M. olifera	15.09 a	15.80 a	15.44 a	74.54	71.85	73.195
Mix (1:1:1)	14.43 b	14.17 b	14.30 b	72.08	71.55	71.815
F. test	*	*	*	NS	NS	NS
Plant extract concentration						
50 %	12.75 b	12.55 b	12.65 b	68.08 c	75.74	71.91
75 %	14.94 a	14.65 a	14.79 a	78.45 a	73.30	75.88
100 %	13.42 b	13.14 b	13.28 b	74.35 b	77.91	76.13
F. test	*	*	*	*	NS	NS
Potassium timing						
Pre sowing	13.10 b	12.85 b	12.97 b	74.20	78.53 a	76.37
30 DAS	14.05 a	13.79 a	13.92 a	73.64	75.92 b	74.78
60 DAS	13.98 a	13.73 a	13.85 a	77.86	72.18 c	75.02
F. test	*	*	*	NS	*	NS
Interaction effects						
Plant extract * Concentration	*	*	*	NS	NS	NS
Plant extract * Potassium timing	*	*	*	NS	NS	NS
Concentration * Potassium timing	NS	NS	NS	NS	*	NS
Extract*Concentration*Potassium	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

* and ** refer to significance at 5% and 1% levels of probability. NS denote non-significance.

As a result of spraying plant extracts, results in Table 4 illustrate that foliar spraying with *Moringa* and *Chinopodium* extracts reasonably produced the highest protein content *i.e.* 15.44% and 15.02%, respectively. Spraying with distilled water as a check treatment resulted in the lowest protein content (11.71%). Weed suppression as an impact of foliar spraying with aqueous extracts through the allelopathic effects was clear through affecting significantly the number and dry weight of weed plants. Results of both number and weight of weeds/m^2 in Table 5 assure the role of extracts in obstruct weeds growth. The lowest No. of weeds/m^2 (47.43) and the lowest weed dry weight/m^2 (68.63 g) combined data were the result of foliar spray with the mixture of the three plant extracts ((*Chinopodium* + *Lantana* + *Moringa*).

Both No. of weeds/m^2 and its dry weight (g/m^2) recorded the highest values under control treatment (distilled water). *Chinopodium* extract ranked second in weed control following spraying by the mixture of all extracts.

The obtained results declare the diacritical function of plant leaf extracts as growth promoters and stress the need to use it as a novel strategy to lessen reliance on costly mineral fertilizers and hazardous chemical growth promoters. Furthermore, because the botanical extracts are allelopathic compounds, they offer a novel and inexpensive method of controlling weeds, particularly in organic farming.

Impacts of the Aqueous Extract Concentration

Concentration of plant leaf extracts had significant effects on biological yield in the 2nd season and the combined analysis. Raising concentration from 75% to 100% was non additive and insignificantly affected biological yield (Table 2) and harvest index (Table 3) in the 1st season and the combined. Wheat plants treated with extracts 75% concentration recorded the highest biological yield (5519.28 kg/fad.) as shown from the combined analysis (Tables 2 and 3).

Taking into account the combined analysis in Tables 4 and 5, spraying wheat plants with 75% concentration of the aqueous leaf extract led to the highest grain yield (2649.85 kg/fad), harvest index (0.425) and crude protein content (14.79%). Harvest index values under spraying with 75% or 100% concentration were in co-ordinate.

Allusion to the meta-analysis of the two seasons (Table 5) both number and dry weight of weeds/m^2 obviously decreased in each raising in the aqueous leaf extract from 50 to 100%, the lowermost No. of weeds/m^2 (57.96) and weed dry weight (82.53 g) were the resultant of spraying the highest concentration. Spraying extracts at 50% concentration remained the higher number of weeds with less suppression; and that results might explain the higher level of nutrients and allelophatic components provided through the higher concentration of sprayed plant extracts.

Impacts of the Potassium Application Timing

According to the results presented in Tables 1, 2, 3, 4 and 5, potassium timing had significant impacts on all studied traits except TC which was significant only in the 2nd season. Adding potassium early at soil preparation and directly before sowing recorded the highest value in each of No. of tillers/m^2 (727.5), No. of spikes/m^2 (500.7), grain yield (2525.96 kg/fad), harvest index (43 %) as combined.

Adding potassium pre-sowing and 30 DAS achieved the same higher level of significance in biological yield and No. of grains/spike which explain the importance of adding potassium in early growth stages to help in maximizing the efficiency of dry matter translocation, and thus, the physiological activity is translated into higher biological yield and grain filling (**Irshad *et al.*, 2022**). Adding potassium at advanced growth age (60 DAS) recorded the lowest yield components, and thus, the lowest grain yield in the 2nd season and as combined (2409 kg/fad.). However, adding potassium at 60 DAS recorded the higher significant crude protein content (13.85%), which was at par with adding it at 60 DAS which recorded 13.92%.

Potassium had a great role in weed suppression due to its supportive role in assimilating nutrients, which make wheat plants more competitive to weed plants, through rapid and stronger growth expressed as more competitive ability. Results in Table 4 indicate that potassium timing significantly affected on coverlet components (weeds number and dry weight/m^2).

Potassium added during soil preparation and directly before sowing (pre-sowing) recorded the lowest number of weeds/m^2 (55.685) and the lowest dry weight (83.51 g/m^2); while adding potassium at 30 and 60 days after sowing resulted in mainly the double amounts of weed coverlet components. As mentioned by **Fayed *et al.* (2018)**, the critical period to control weeds is the early growth stages from 2 to 6 weeks after sowing, and that explains the reason why the obtained results are in favor of adding potassium at early time (pre-sowing).

Impacts of the Interaction among the Study Factors

Referring to the combined results, it can be shown that the interaction between the sprayed extracts and their concentrations had a substantial significant impact on biological and grain yields, harvest index, and protein content (Tables 1, 2, 3 and 4). The interaction efficacy among extracts and its concentrations is in vain on the other traits under study. It's worth mentioning that the affected traits under previous interactions were taking the same trend as its manner under the main factors under study, so results were not displayed.

The interaction between extracts types and potassium timing was efficient on all studied traits with the exception of biological yield, No. of grains/spike, 1000 grain weight and TC content. The effect of the interaction (Extract type × Concentration) was in analogous to the effect of main factors on those traits; accordingly.

The interaction between extracts concentrations and potassium timing exhibited operative act on biological yield, 1000 grain weight, weeds dry weight (g/m^2). It is worth to mention, it has been noted that the response of the studied traits under the interaction between extracts concentrations × potassium timing and the main factors was on a par, so results of the interactions have not been presented.

Weeds Reduction Percentage Due to Plant Extracts (Weeds Suppression Efficiency)

Figs. 1 and 2 display the reduction percentage in weed coverlet components per unit area as a result of foliar spraying of plant extracts which indicate efficiency or/and effectiveness of the experimented plant extracts on weed suppression (Table 5). It could be concluded that both weed traits (number and dry weight) are two sides of the same coin as affected by plant extract type. Results indicated that spraying wheat plants by the mixed extract from the 3 plant spices together (*C. album* + *M. olefeira* + *L. camara*) recorded the highest reduction percentage in both weed components as combined by 40.40% and 31.99% for weeds number and dry weight, respectively. Spraying the extract from *C. album* ranked 2nd in suppressing weed components as combined by a reduction percentage amounted to 32.87% and 21.10% for weeds number and dry weight, respectively.

Conclusion

Using aqueous extracts from different plant species is a new approach for sustaining the agricultural production while using organic sources for more productivity and more reduction of agricultural pollution. Spraying wheat plants with leaf extracts at the proper concentration significantly improved various characteristics of wheat plants producing higher yield and stimulating dry matter accumulation. Potassium supply time is a serial key for enhancing growth and increasing its ability to suppress weed coverlet.

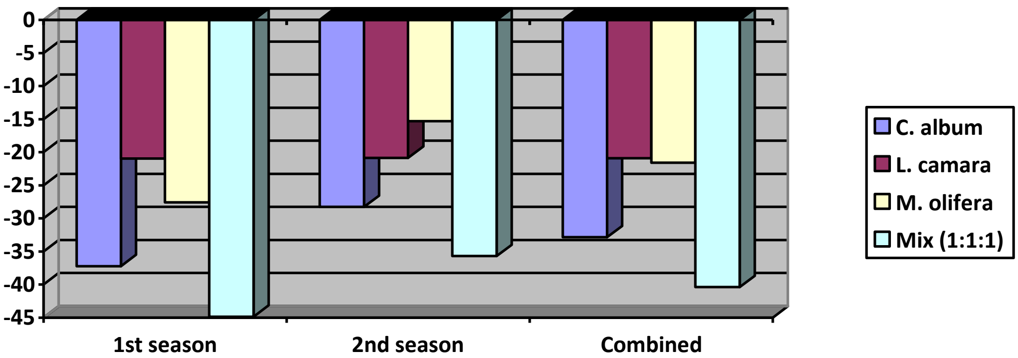

Fig. 1. Plant extracts efficiency on suppression number of weeds/m^2

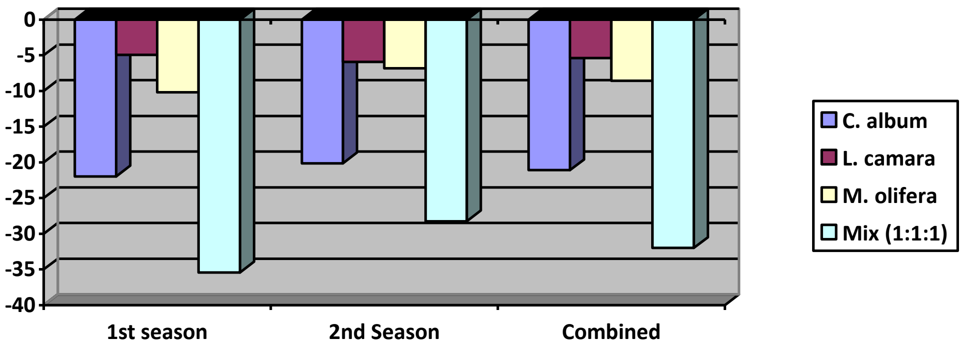

Fig. 2. Plant extracts efficiency on suppression weeds dry weight/m^2

Table 5. Weeds coverlet (No. of weeds and weeds dry weight (g/m^2) as affected by the concentration and type of leaf extract as well as potassium application time

Main effects and interaction	No. of weeds/m^2			Weeds dry weight (g/m^2)		
	2020-21	2021-22	Comb.	2020-21	2021-22	Comb.
Plant extract						
Check (distilled water)	81.5 e	77.66 d	79.58 d	105.22 d	96.6 d	100.91 e
C. album	51.14 b	55.70 b	53.42 b	82.10 b	77.15 b	79.62 b
L. camara	64.42 d	61.46 c	62.94 c	100.02 d	90.88 c	95.45 d
M. olifera	59.02 c	65.78 c	62.4 c	94.52 c	89.98 c	92.25 c
Mix (1:1:1)	44.94 a	49.92 a	47.43 a	67.94 a	69.31 a	68.63 a
F. test	*	*	*	*	*	*
Plant extract concentration						
50 %	63.74 b	64.29 b	64.015 c	97.43 b	87.14 b	92.28 c
75 %	59.28 a	63.66 b	61.47 b	87.25 a	86.81 b	87.03 b
100 %	57.58 a	58.33 a	57.955 a	85.21 a	79.86 a	82.53 a
F. test	NS	*	*	*	*	*
Potassium timing						
Pre sowing	52.88 a	58.49 a	55.685 a	82.23 a	84.79	83.51 a
30 DAS	62.74 b	61.86 b	62.30 b	94.11 b	86.08	90.10 b
60 DAS	68.8 c	65.95 b	67.375 c	93.54 b	82.95	88.24 b
F. test	*	*	*	*	NS	*
Interaction effects						
Plant extract * Concentration	*	*	*	*	*	*
Plant extract * Potassium timing	NS	*	*	*	*	*
Concentration * Potassium timing	NS	NS	NS	**NS**	**NS**	**NS**
Extract*Concentration*Potassium	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

* and ** refer to significance at 5% and 1% levels of probability. NS denote non-significance.

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تحسين إنتاجية القمح وتثبيط نمو الحشائش اعتماداً على ميعاد إضافة البوتاسيوم وتراكيز مختلفة من بعض المستخلصات النباتية

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تم إجراء تجربتان حقليتان فى أرض رمليه بمزرعه خاصة تقع في منطقة قصاصين الشرق، الحسينية، مركز فاقوس، محافظة الشرقية، مصر، وذلك خلال الموسمين الشتويين 2021/2020 و2022/2021 على قمح الخبز صنف جميزة 11. هدفت الدراسة إلى تقييم تأثير رش النباتات بثلاثة مستخلصات نباتيه لأوراق ثلاثة أنواع نباتيه (المورينجا، الزربيح واللانتانا، ومخلوط من الثلاثة أنواع بنسبة 1:1:1 بالإضافة إلى الماء المقطر كمعاملة كنترول) على نمو ومحصول وجودة نباتات القمح. جُرِّبَت المُستخلصات النباتيه بثلاثة تراكيز مختلفه لكل منها (50، 75 و100%). ومن جهة أخرى هدفت الدراسة إلى تقييم استجابة القمح لثلاثة مواعيد مختلفه لإضافة السماد البوتاسى (قبل الزراعه، 30 يوماً بعد الزرعه و 60 يوماً بعد الزراعة). استهدفت الدراسة أيضاً بحث نتيجة المعاملات المذكورة فى تثبيط نباتات الحشائش من خلال تقدير عددها ووزنها فى وحدة المساحة. استُخدِمَ لتنفيذ التجربه تصميم القطع المنشقة مرتين في ثلاث مكررات. أوضحت النتائج أن رش نباتات القمح بالمستخلصات النباتية المذكورة كان له تأثير معنوي على جميع الصفات المسجلة ماعدا عدد الأشطاء/م^2، عدد حبوب السنبلة ومحتوى الكربوهيدرات الكلى. حققت المُعامله بمستخلص الزربيح أكبر قيمة للمحصول البيولوجى، ودليل البذور (وزن الألف حبة). حققت المُعامله بمستخلص اللانتانا محصول حبوب عالى فى حين حققت المُعامله بمستخلص المورينجا أكبر محصول بيولوجى ودليل بذور. أدى الرش الورقي بهذه المستخلصات إلى تحفيز تراكم المادة الجافة. سجلت المُعامله بمستخلصى الزربيح والمورينجا المائيين أعلى محتوى من البروتين بالجبوب؛ كما أدى الرش الورقي بهذه المستخلصات إلى تقليل أعداد وأوزان نباتات الحشائش المنتشرة بوحدة المساحة على اختلاف أنواعها. من جهة أخرى كان لتركيز المستخلصات النباتية تأثير معنوي على المحصول البيولوجي، حيث سجل تركيز المستخلصات المرشوشة بنسبة 75% أقل عدد نباتات حشائش ووزن جاف لها، مما ساهم فى زيادة محصول الحبوب ودليل الحصاد ومحتوى البروتين الخام. كان لتوقيت إضافة البوتاسيوم تأثير معنوي على جميع الصفات باستثناء مكافحة الحشائش، حيث كانت الإضافة المبكرة هى أجدى مواعيد الإضافه. لعب البوتاسيوم دورًا فعَّالاً في مكافحة الحشائش من خلال التفاعل مع الرش الورقى للمستخلصات النباتيه مما جعل نباتات القمح أكثر قدرة على المنافسة مع نباتات الحشائش، وعليه يُوصى بإضافة البوتاسيوم في المراحل المبكرة من النمو. ختاماً فإن للتفاعل بين المستخلصات النباتيه والتراكيز أثر معنوي على المحصول البيولوجي ومحصول الحبوب ودليل الحصاد ومحتوى البروتين الخام؛ وكذلك التفاعل بين المستخلصات النباتيه وتوقيت إضافة البوتاسيوم. بحساب كفاءة استخدام المستخلصات النباتيه، وجدت الدراسة أن رش نباتات القمح بمخلوط الزربيح واللانتانا والمورينجا بنسبة 1:1:1 قد حقق أعلى نسبة انخفاض في مكونات الحشائش (عدد و وزن نباتات الحشائش/م^2)، ويأتى فى المقام الثانى استخدام مستخلص الزربيح منفرداً.

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