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Synergistic and Antagonistic Effects Between Some Wheat Herbicides and Gibberellic Acid (GA_3) Tank-Mix on Some Wheat Varieties Productivity and Associated Weeds

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Abstract: A field experiments were conducted to determine if gibberlic acid (GA_3) addition to some wheat herbicides can improve the herbicides efficacy on weeds and thus achieve the yield potential of wheat in sandy soils. The experiment was established with a split-plot design having four replicates. The main plots included four varieties and subplots were assigned to five weed control treatments. The main plots were wheat varieties (Sakha 93, Sakha 94, Giza 168 and Gemmeiza 9). Subplots were weed control treatments, which consisted of (1) unweeded check ; (2) hand weeding twice ; (3) fluroxypyr applied at 100 g ae/ha; (4) Bentazon applied at 2.38 l/ha; and (5) Fumetsulam + Florasulam herbicide at 71.4 cm^3/ha. The results indicated that the lowest dry weight of weeds was observed in Giza 168 and Gemmeiza 9 cultivars plots, while the highest dry weight of weeds was observed with Sakha 93 cv. The rank order of competitive ability of the four wheat cultivars to weeds was Giza 168 > Gemmeiza 9 > Sakha 94 > Sakha 93. The highest weed control efficiency (WCE) in wheat field at 9WAS was significantly influenced by weed management treatments and the highest WCE (>91.7%) was recorded with Florasulam+Flumetsulam herbicide with or without addition GA_3 in the spray solution. The control percent of each herbicide was depend on the weed specie, where Bentazon herbicide completely controlled *Sonchus oleraceus* while its efficacy on *Emex spinosus* did not increase than 71.2%. Application of Fluroxypyr herbicide alone gave 73-95% control of *Emex spinosus*; while the tank-mixture of GA_3 with the same herbicide resulted in completely control of this weed. The similar synergetic effect was noticed with Florasulam+Flumetsulam herbicide on *Anagallis arvensis*. The highest increase in the plant height (25%), number of tillers (28.5%) and the dry weight of plants (11.7%) due to addition of GA_3 with Bentazon, Florasulam+Flumetsulam and Fluroxypyr herbicides, respectively, compared to each herbicide alone. Un-controlling the wheat weeds significantly decreased the grain yield/ha by 38.8% relative to hand weeding treatment. Using bentazon, Florasulam+Flumetsulam and Fluroxypyr herbicides without GA_3 addition controlling the wheat weeds and increased the grain yield than the unweeded check by 67.2, 92.5 and 61.4%, respectively. There is synergistic effect between the growth regulator GA_3 and the Bentazon and Fluroxypyr herbicides, where the grain yield/ hectare was increased by 20.1 and 12.3% compared to each herbicide applied alone, respectively. On the other hand there was antagonistic effect between tankmixture of GA_3 and Florasulam+Flumetsulam on wheat grain yield where addition GA_3 to the herbicide resulted in a reduction in the grain yield by 21.6% relative to the herbicide alone. The greatest grain yield was obtained when sowing Gemmeiza 9 variety and controlling the weeds by Florasulam+Flumetsulam herbicide which didn't differed statically with Sakha 93 cv under Bentazon+ GA_3 or hand weeding in Gemmeiza 9 variety.

Key words: GA_3 · Weeds · Herbicides · Wheat · Interaction · Bentazon · Florasulam+Flumetsulam · Fluroxypyr

INTRODUCTION

Weed/crop competition is a major factor limiting food production worldwide. For example, in China 10 million metric tons of rice is estimated to be lost annually due to weed competition [1], enough rice to feed 56 million people for 1 year [2]. Abbas *et al.* [3] reported that weeds are one of the major constraints in wheat production as they reduce productivity due to competition [4], allelopathy [5], by providing habitats for pathogens and

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thus severing as alternate host for various insects and fungi and increase harvesting costs [6]. In addition, weeds limit wheat yield potential in arid region [7] because they increase evapotranspiration and compete with wheat plants for limited soil moisture, water and light resulting in grain yield reduction amounted to 7% [8], 41%. [9], 66% [10], 92% [11] and in serious cases may lead to complete crop failure [12]. In view of the techniques and methods of weed management around the world, chemical control is largely adopted [13, 14]. Therefore, ways to increase herbicide activity, as well as, to achieve effective control of the herbicide are very important. Bentazon, Fluroxypyr and Fumeetsulam+Florasulam (Derby) are a post-emergence herbicide with high selectivity, is commonly used for controlling weeds in wheat and barley crops [15, 16].

The addition of an adjuvant increase herbicidal activity [17] and modify environmental fate [18]. Enhanced herbicide efficacy generally reflects increased herbicide absorption; however, increased herbicide absorption does not always correlate with increased efficacy [19]. Singh and Singh [19] reported that the efficacy of foliar applied herbicides is greatly influenced by adjuvants, but not all adjuvants have a synergistic effect. They added that adjuvant usage improved the efficacy of fomesafen more than it did with bentazon on velvetleaf, *Ambrosia artemisiifolia* L, *Solanum ptycanthum* Dun. and *Solanum sarrachoides* Sendtner.

Growth regulators play an important role in the plant growth and productivity [20- 22] and enhance the herbicides control efficacy [23]. Tagour *et al.* [23] found that application of Harmony (hormones) + Topic herbicide gave the highest reduction of weeds and the highest grain yield of wheat. Tankmix of some bio-regulators with herbicides enhanced the herbicide efficacy on the weeds. The benefit of the synergy came from bio-regulators and herbicides mixture may reduce the herbicide application rate required for effective weed control. Silverman *et al.* [24] reported that sodium salicylate (sodium 2-hydroxybenzoate; NaSA) increased the post emergence herbicidal activity of atrazine against dicotyledonous weeds. NaSA also potentiated the activity of bentazon, another PSII-inhibiting herbicide. NaSA increased atrazine activity when applied either as a tank mix or up to 96 h prior to atrazine application. Dickson *et al.* [25] mentioned that addition of 200 µg GA into the leaf sheaths 2 days prior to spraying with fluazifop or glyphosate increased the efficacy of both herbicides at low N. Sterrett *et al.* [26] reported that pretreatment of Canada thistle plants in the growth chamber with 100 mg/l $GA_{4/7}$ increased the herbicidal effect of 50 mg/L bentazon applications more than four-fold and that of 400 mg/L glyphosate applications by more than two-fold. The phytotoxicity of bentazon to field-grown Canada thistle increased 10% or more in populations pretreated with 25 g/ha gibberellin; and that of 840 g/ha glyphosate was similarly increased. The effectiveness of a higher glyphosate dosage (1680 g/ha) was not significantly increased by GA_3 pretreatment. Plants induced to bolt with gibberellin ($GA_{4/7}$) were injured more by bentazon than were plants that bolted naturally.

Use of aggressive cultivars can be effective cultural practice for weed growth suppression [27-30]. According to Bussan *et al.* [31] the competitive ability of crop can be expressed in two ways. First is the ability of the crop to compete with weeds, reducing weed seed and biomass production. The second possibility is having crop tolerate competition from weeds, while maintaining high yields. Hucl [32] found that the less competitive genotypes suffered a 7-9% greater yield loss than that of the more competitive genotypes. On the other hand, Cardina [33] concluded that more competitive cultivars are not necessarily higher yielding. Mason *et al.* [34] reported that tallness and early heading and maturity were related to increase grain yield at the highest weed level. Greater spikes/m^2, tallness and early heading were associated with reduced weed biomass, depending on weed level. The response of wheat plants to herbicides also varied among cultivars [9, 35].

The objectives of this research were to examine the effect of addition giberellic acid (GA_3) tank mixture with Fluroxypyr, Bentazone and Fumeetsulam + Florasulam herbicides on four wheat varieties productivity and associated weeds.

MATERIALS AND METHODS

Field experiments were conducted at Salhia district, Sharkia Governorate, Egypt during the winter season of 2008/2009 and 2009/2010 to investigate the effect of tank-mix GA_3 with some broadleaved herbicides on wheat varieties productivity and associated weeds under sandy soil condition. The soil was sandy with pH 7.7, organic matter 1.75%, E.C. 1.32 mmohs/cm, $CaCO_3$ 1.40%, total N 0.088%, total P 0.056% and total K 0.027%. Plot area was 10.5 m^2 (3 m width by 3.5 m length). The experiment was established with a split-plot design having four replicates. The main plots included four wheat varieties and subplots were assigned to five weed control treatments. The main plots were wheat varieties namely Sakha 93, Sakha 94, Giza 168 and Gemmeiza 9. Subplots were weed control treatments, which consisted of (1) unweeded check (weeds were allowed to grow with wheat plants); (2) hand weeding two times at 4 and 7 weeks after sowing (WAS) of wheat weeks, (3) Fluroxypyr (Starane) herbicide applied at 100 g ae/ha, (4) Bentazon (Basagran; AS 48%) herbicide applied at 2.38 L/ha; and (5) (75g/l florasulam+100g/l flumetsulam) (Derby 175 SC) herbicide at 71.4 cm^3/ha. The three herbicides were sprayed at 4 weeks after wheat sowing (WAS) with knapsack sprayer with 476 litres water spray volume per hectare. The growth regulator was gibberllic acid 10% (GA_3) [(2, 4a, 7-trihydroxy-l-methyl-8-methylenegibb-3-ene-1,10-carboxylic acid 1-4 lactone] was added in tankmixure at 50ppm. Wheat seeds of four varieties were sown on the second week of November in both seasons, using a constant seeding rate (200 kg/fed). The wheat plants received 225, 56 and 60 kg/ha of N, P_2O_5 and K_2O kg/ha, respectively. Phosphorus and potassium fertilizer were applied during the soil preparation and at the 3rd irrigation, respectively, while the nitrogen fertilizer was applied in three equal portions at the 1st, 3rd and 5th wheat irrigation. The normal cultural practices for growing wheat in sandy soil were applied as recommended, except for weed control measures. Furrow irrigation system was used.

Data Recorded: Visual weed control was estimated on a percentage scale from 0 (no control) to 100 (death) at 7 WAS. Dry weight of weeds: after 9 WAS a quadrat of 0.5 m x 0.5 m was placed at random inside the each plot. The above ground portion of the weeds in the quadrat was removed from each plot. Weed samples were air-dried and later oven dried to constant weight at 70°C and dry weight was recorded separately for weeds and a summation of the weeds were recorded as the total dry weight in grams. These dry weights were converted to dry weight per square meter. Weed control efficiency: The weed control efficiency (WCE) was calculated by adopting the formula given by Mani *et al.* [36].

$$\text{WCE (\%)} = \frac{\text{Weed dry weight of weedy check - weeded dry weight of treatment}}{\text{Weed dry weight of weedy check}} \times 100$$

Data Transformation: The data on weed count and weed dry weight showed high degree of variation. Therefore, the weed count data was subjected to square-root transformation and data on dry weight of weeds was subjected to logarithmic transformation to make the analysis of variance valid as suggested by Gomez and Gomez [37]. At 9WAS, plant height, number of tillers/m^2 and dry weight/m^2 of wheat plants were recorded (nearest to the correct number). At harvest, a plant sample of one square meter from each plot was taken to determine tillers fertility (%), spike length, and grain weight per spike. Biological and grain yields per hectare were determined by harvesting the whole plot area.

Statistical Analysis: Combined analysis of data for the two growing seasons was carried out according to Snedecor and Cochran [38]. For comparison between means, L.S.D. test at 5% level was used.

RESULTS AND DISCUSSION

Weeds

Weed Flora: Among the different weeds prevailed in the experimental field the most common weeds comprised Prickly dock (*Emex spinosus* Campd (L)*;* Sow thistle (*Sonchus oleraceus* L.); Scarlet Pimernel (*Anagallis arvensis* L.) and Goose foot *(Chenopodium murale* L.). The rest of the weeds were of little importance having negligible weeds infestation. The lowest dry weight of weeds was observed in Giza 168 and Gemmeiza 9 cultivars plots, while the highest dry weight of weeds was observed with Sakha 93 cv (Table 1). They reduced the weight of weeds by 39.4% and 36.3%, respectively if compared to Sakha 93 cv. This means that Sakha 93 cultivar was less competitor variety if compared with the three varieties. The rank order of competitive ability of the four wheat cultivars to weeds was Giza 168 > Gemmeiza 9 > Sakha 94 > Sakha 93. The competitive advantage of Gemmeiza cv. than sakha93 cv. may be due to the more tillers number/m^2. It could be mentioned that- nearly- the tillers number take the same direction of competitive order, where the competitor cultivars have the highest number and the sensitive cultivar have the fewest one. Also the smother variety was taller (31cm) than the sensitive variety one (28cm) and more vegetative growth as expressed by the highest dry weight at 9 WAS. Cosser *et al.* [39] suggest that the traditional tall cv. Maris Widgeon could be used beneficially to tolerate weeds in organic systems when high weed infestations were anticipated, but could not be relied upon to suppress weed development and in some circumstances could actually encourage certain species.

Previous studies indicated that some wheat cultivars are more competitive than others [9, 29, 30, 40]. The difference in the ability of cultivars to suppress weed growth than other might be due to the differential rooting patterns, allelochemicals production, higher leaf area index and more light interception, tillering capacity and vegetative growth habit [27]. Chopra *et al.* [30] reported that cultivars 'HD 2687', 'HD 2643' and 'HD 2733' smother the weeds more efficiently than the 'HDR 77', 'HD 2380' and 'HD 2329'. 'HD 2687' recorded maximum grain yield across weed control levels which was significantly higher than the 'HDR 77', 'HD 2380' and 'HD 2329'. Insignificant differences were noticed in the weed density between the four wheat varieties (Table 1). Among the different weed management treatments (Table 1), post-emergent application of Florasulam + Flumetsulam herbicide recorded the lower total dry weight of weeds as compared to other weed management treatments. While, Fluroxypyr herbicide recorded the lower efficacy on the weed density, with insignificant difference with bentazon herbicide treatment. The highest weed control efficiency (WCE) in wheat field at 9WAS was significantly influenced by weed management treatments and the highest WCE (>91.7 %) was recorded with Florasulam + Flumetsulam herbicide with or without addition GA_3 in the spray solution. Similar finding was reported by Baghestani *et al.* [42]. While, the lowest WCE was observed with Fluroxypyr 79.6% (Table 1). Abbas *et al.* [3] and Mustafee [41] reported that fluroxypyr post-emergence give effective weed kill in wheat field. Hand weeding gave 82.4% WCE and decreased the weed density by 90% (Table 1). Data in Table 2 indicated that the control percent of each herbicide was depend on the weed specie, where Bentazon herbicide completely controlled *Sonchus oleraceus* weed, while its efficacy on *Emex spinosus* did not increase than 71.2% species. Baghestani *et al.* [42] reported that herbicide efficiency in controlling weeds differs according to weed species.

Concerning the effect of addition GA_3 to the herbicides tank mix on dry weight of weeds at 9WAS, the results indicated that overall weed control was greater when GA_3 was applied tank-mixed with the herbicides than each herbicide applied alone (Table 1). At 9 weeks after sowing (WAS), *Sonchus oleraceus*, *Anagallis arvensis* and *Chenopodium murale* were completed controls when bentazon was applied alone or in combination with GA_3.

Bentazon herbicide was little effect on *Emex spinosus* weed, but its efficacy was improved with addition the growth regulator GA_3 in tankmixture. Addition of GA_3 tankmixure with herbicides on weeds was varied according to the herbicide and the weed specie (Table 2). Fluroxypyr herbicide alone gave 73-95% control of *Emex spinosus*; while the tank-mixture of GA_3 with the same herbicide resulted in completely control of this weed. The similar synergetic effect was noticed with Florasulam+Flumetsulam herbicide on *Anagallis arvensis* (Table 2). On the other hand some antagonistic effect was observed from addition GA_3 with Florasulam+Flumetsulam on *Emex spinosus* weed, Fluroxypyr on *Sonchus oleraceus* and Florasulam + Flumetsulam and Fluroxypyr on *Chenopodium murale* (Table 2). Synergistic and antagonistic effect of addition the growth regulators to the herbicide were observed by Sharara *et al.* [10], Tagour *et al.* [23] an and Ferrell and Alley [43]. Ferrell and Alley [43] reported that cytokinin and gibberellin did increase the activity of the herbicides (dicamba (3, 6-dichloro-o-anisic acid) and picloram (4-amino-3, 5, 6- trichloropicolinic acid) on leafy spurge.

Table 1: Effect of wheat varieties and weed control management and their interaction on weed density and total dry weight of weeds (Combined analysis of the two seasons)

	Wheat cultivars										
	Gem 9	Sak 93	Sak 94	Giza 168	Mean	Gem 9	Sak 93	Sak 94	Giza 168	Mean	WCE
Treatments	Weed density % at 7WAS					Total dry weight of weeds (g m^2) at 9WAS					
Control	80	88	80	75	81	94.8	115.4	84.0	65.2	89.9	0.0
Bentazon	20	23	20	17	20	13.2	12.0	24.0	18.8	17.0	81.1
Bentazon+ GA_3	4	5	5	5	5	6.4	14.0	20.0	12.8	13.3	85.2
Florasulam+Flumetsulam	12	10	10	8	10	8.8	17.2	4.0	00.0	7.5	91.7
Florasu+Flumet +GA_3	10	11	10	9	10	7.2	4.0	13.6	04.4	7.3	91.9
Fluroxypyr	26	25	27	24	26	5.2	25.6	25.6	16.8	18.3	79.6
Fluroxypyr +GA_3	23	25	26	25	25	4.8	29.2	16.8	12.4	15.8	82.4
Hand weeding	11	12	10	7	10	4.4	10.0	6.0	7.2	6.9	92.3
Average	23	25	24	22	23	18.1	28.4	24.3	17.2		
LSD at 5% for :											
Varieties	NS					3.2					
Weed Control	12					6.1					
Interaction	NS					11.5					

Gem: Gemmeiza, Sak: Sakha, WCE: Weed control efficiency, Floras: Florasulam, Flumet: Flumetsulam, GA_3: Gibberelic acid

Table 2: Effect of wheat varieties and weed control management and their interaction on the dry weight of weeds (g m^2) at 9WAS (Combined analysis of the two seasons)

	Wheat cultivars									
	Gem 9	Sakha 93	Sakha 94	Giza 168	Mean	Gem 9	Sakha 93	Sakha 94	Giza 168	Mean
Treatments	*Emex spinosus*					*Sonchus oleraceus*				
Control	51.2	41.6	36.0	38.4	41.8	21.2	36.0	17.6	14.4	22.3
Bentazon	13.2	12.0	24.0	18.8	17.0	0.0	0.0	0.0	0.0	0.0
Ben+ GA_3	6.4	14.0	20.0	12.8	13.3	0.0	0.0	0.0	0.0	0.0
Florasulam+Flumetsulam	0.0	0.0	0.0	0.0	0.0	1.6	2.4	0.0	0.0	1.0
Floras+Flumet + GA_3	0.0	1.2	0.4	1.2	0.7	0.0	2.8	1.6	2.4	1.7
Fluroxypyr	2.8	5.6	8.0	10.4	6.7	0.0	1.6	1.6	3.6	1.7
Fluroxypyr +GA_3	0.0	0.0	0.0	0.0	0.0	2.0	18.0	8.0	6.0	8.5
Hand Weeding.	0.4	2.4	1.2	0.8	1.2	2.4	2.0	0.8	2.8	2.0
Average	9.3	9.6	11.2	10.3		3.4	7.9	3.7	3.7	0
LSD at 5% for										
Varieties	2.8								3.6	
Weed Control	5.5								6.8	
Interaction	NS								NS	
	Anagallis arvensis								*Chenopodium murale*	
Control	12.4	23.8	11.6	7.2	13.8	10.0	14.0	18.8	5.2	12.0
Bentazon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bentazon+ GA_3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Florasulam+Flumetsulam	7.2	10.4	4.0	0.0	5.4	0.0	4.4	0.0	0.0	1.1
Floras+Flumet + GA_3	0.0	0.0	0.0	0.0	0.0	7.2	0.0	11.6	0.8	4.9
Fluroxypyr	2.4	9.6	8.4	0.0	5.1	0.0	8.8	7.6	2.8	4.8
Fluroxypyr +GA_3	0.0	3.6	0.0	3.6	1.8	2.8	7.6	8.8	2.8	5.5
Hand Weeding	1.6	3.2	3.2	2.4	2.6	0.0	2.4	0.8	1.2	1.1
Average	3.0	6.3	3.4	1.7		2.5	4.7	6.0	1.6	
LSD at 5% for:										
Varieties	2.9								1.3	
Weed Control	5.5								2.5	
Interaction	8.2								3.8	

Gem:Gemmeiza, Floras: Florasulam, Flumet: Flumetsulam, GA_3: Gibberelic acid

Table 3: Effect of wheat varieties and weed control management and their interaction on plant height, tillers number and dry weight of wheat plants at 9 weeks after wheat sowing (Combined analysis of the two seasons)

	Gem 9	Sakha 93	Sakha 94	Giza 168	Mean	Gem 9	Sakha 93	Sakha 94	Giza 168	Mean	Gem9	Sakha 93	Sakha 94	Giza 168	Mean
Treatments	Plant height (cm)					Tillers number/m^2					Plant dry weight (g m^{-2})				
Control	60	56	58	56	58	432	400	480	432	436	404	422	545	505	469
Bentazon	62	54	60	62	60	564	544	560	464	533	540	514	557	662	568
Bentazon+ GA_3	66	60	66	68	65	544	576	544	576	560	551	619	557	710	609
Floras+Flumet	58	52	60	56	57	706	468	528	512	554	542	485	754	599	595
Flors+Flumet+GA_3	58	56	66	62	61	880	544	624	800	712	538	489	551	778	589
Fluroxypyr	50	56	60	54	55	768	384	496	528	544	522	758	576	638	624
Flurox +GA_3	62	60	68	70	65	672	544	528	528	568	725	686	594	783	697
Hand Weeding	68	56	58	64	62	608	496	656	512	568	619	499	696	643	614
Average	61	56	62	62		647	495	552	544		555	559	604	665	
LSD at 5% for:															
Varieties	6					37					41				
Weed Control	12					70					78				
Interaction	NS					NS					NS				

Gem: Gemmeiza, Floras: Florasulam, Flumet: Flumetsulam, GA_3: Gibberelic acid

Wheat Growth: Data in Table 3 indicated that Gemmeiza 9 cv was the tallest variety while Sakha cv was the shortest one. On the other hand, Giza 168 produced significantly more number of tillers/m^2 than Sakha 93 by 9.7% and surpassed Sakha 93, Sakha 94, Gemmeiza 9 varieties in the dry weight of wheat plants/m^2 criteria by 19.8, 18.9 and 8.5%, respectively (Table 3).

No phototoxic was observed on wheat plants by tank mixing GA_3 with Fluroxypyr, Fumetsulam + Florasulam or Bentazon herbicides treatments (personal observation). The results in Table (3) illustrated clearly that controlling the wheat weeds caused a significant increments in the tillers number and the dry wheat of wheat plants. Similar finding was reported by El-Metwally and Saudy [44]. Application of Fluroxypyr herbicide with or without GA_3 gave the heaviest wheat plants/m^2 than the two herbicides and hand weeding treatments. Regarding to the effect of tankmixed GA_3 with herbicides on wheat vegetative growth, it's clearly noticed that addition of GA_3 caused a significant increments of vegetative growth criteria studied (Table 3). The highest increase in the plant height (25%), number of tillers (28.5%) and the dry weight of plants (11.7%) due to addition of GA_3 with Fluroxypyr, Florasulam+Flumetsulam and Fluroxypyr herbicides treatment, respectively, compared to each herbicide alone. The effect of the interaction between wheat varieties and weed control treatments had insignificant effect on the vegetative growth characters as shown in Table 3.

Wheat Yield: Grain wheat yield was greater for all herbicide treatments and hand weeding compared to the weedy check. This result showed that application of GA_3 in combination with broadleaf weed herbicides provided excellent weed control in wheat (Tables 1 and 2). Tiller fertility percentage was significantly affected by the two factors studied (Table 4), where the highest tiller fertility percent was recorded with Giza 168 cv and significantly surpassed Sakha 93, Sakha 94 and Gemmeiza varieties by 6,7 and 3%, respectively. While, Sakha 94 gave the highest grain weight per spike. Spike length character was unaffected by the varieties and weed control treatments and their interaction. Controlling the weeds grown associated with wheat plants resulted in the increments in the tiller fertility percent and the superior treatment was Florasulam+Flumetsulam+GA_3 (100%). Ashiq *et al.* [45] found that herbicidal treated units produced 33-44% more fertile tillers than the weedy check, which contributed a lot to the final grain yield. Gemmeiza 9 variety produced the heaviest biological yield/m^2 and significantly exceeded than Giza 168 cv by 12.6% (Table 4). This result may be to that this superior variety had more number of tillers/m^2 (Table 2). All weed management treatment significantly increased the biological yield of wheat plants than unweeded check. Application of Bentazon resulted in the highest biological yield followed by hand weeding treatments. Data in Table 4 clearly indicated that addition of GA_3 with Bentazon herbicides tankmixture caused an increase in the biological yield by 17.7% than the herbicide alone. On the contrary there was no additive and negative effect on the biological yield due to addition of GA_3 with Florasulam + Flumetsulam or Fluroxypyr herbicides.

The biological yield was significantly affected by the interaction between heat varieties and weed control management, where the highest biological yield was noticed with Bentazon + GA_3 in Gemmeiza 9 variety, while Fluroxypyr + GA_3 treatment recorded the lowest one. However all unweeded treatment under the four varieties produced the lowest biological yield. These results are in conformity with the findings of Abbas *et al.* [3], Abouziena *et al.* [9] and Nadeem *et al.* [46]. Regarding the grain yield per hectare, data in Table 4 illustrated that grain yield of wheat plants was significantly affected by wheat varieties, weed management and their interaction. The greatest grain yield was produced by cultivation Sakha 94 variety which significantly surpassed Gemmeiza 9 and Giza 168 varieties by 6.6 and 19.7 %, respectively. The differences between cultivars in grain and biological yields might be due to the genetically differences among cultivars and different genotypes concerning dry matter partitioning where wheat cultivars might differ in carbon equivalent yield energy per plant and per hectare [47]. Under weed infestation (unweeded plots) there are significant differences between wheat varieties in grain yield/ha where Giza 168 gave the lowest grain yield however this variety was the tallest plants (Table 3). Un-controlling the wheat weeds significantly decreased the grain yield /ha by 38.8% relative to hand weeding treatments. These results agree with Abbas *et al.* [3] and Marwat *et al.* [48]. The harmful effect of weeds may be attributed to allelopathy of weeds on wheat plants [49], number of spike bearing tillers, grains per spike, net assimilation rate [50] and removal macro and micro-nutrients from soil [51] who reported that weeds left for 9 weeks associated maize plants removed 47, 8 and 29 kg of N, P, K and 58, 630 and 77 g of Zn, Fe and Mn elements per feddan, respectively. Using Bentazon, Florasulam + Flumetsulam and Fluroxypyr herbicides without GA_3 addition controlling the wheat weeds and increased the grain yield than the unweeded check by 67.2, 92.5 and 61.4%, respectively. Application of Florasulam+

Table 4: Effect of wheat varieties and weed control management and their interaction on wheat yield and its related attributes (Combined analysis of the two seasons)

	Wheat cultivars									
	Gem 9	Sakha 93	Sakha 94	Giza 168	Mean	Gem 9	Sakha 93	Sakha 94	Giza 168	Mean
Treatments	Tillers fertility (%)					Spike length (cm)				
Control	80	80	97	98	89	12.2	12.2	12.2	12.6	12.3
Bentazon	88	89	94	96	92	12.8	13.3	12.8	12.6	12.9
Benta+ GA_3	93	93	93	100	95	12.4	12.7	12.6	12.9	12.7
Florasulam+Flumetsulam	90	98	100	100	97	12.8	12.3	12.8	12.6	12.5
Floras + Flumet + GA_3	100	100	100	100	100	12.8	12.2	12.4	12.6	12.4
Fluroxypyr	100	100	94	100	99	12.6	12.3	12.8	12.6	12.4
Fluroxypyr +GA_3	100	96	94	100	98	12.3	12.3	12.8	12.6	12.5
Hand weeding	97	94	100	100	98	12.5	12.8	12.8	12.8	12.7
Average	94	93	97	100		12.5	12.4	12.7	12.6	
LSD at 5% for :										
Varieties	3								NS	
Weed Control	6								NS	
Interaction	NS								NS	
Treatments	Grain weight per spike (g)					Grain yield ((t ha $^{-1}$)				
Control	1.2	1.6	1.8	1.6	1.6	3.17	2.81	3.18	2.41	2.89
Bentazon	2.7	2.3	2.3	2.0	2.3	3.86	3.86	4.16	4.25	4.03
Bentazon+ GA_3	2.6	2.3	2.5	2.5	2.5	4.44	5.28	4.81	3.95	4.84
Florasulam+Flumetsulam	1.9	1.9	2.7	2.2	2.2	5.38	4.31	4.90	3.98	4.64
Floras+Flumet +GA_3	2.1	1.9	1.9	2.0	2.0	3.83	3.20	3.91	3.63	3.64
Fluroxypyr	2.0	1.9	2.6	1.6	2.0	3.35	4.59	4.17	3.45	3.89
Fluroxypyr +GA_3	1.8	1.9	2.5	2.5	2.2	3.59	4.46	5.06	3..63	4.37
Hand weeding	1.8	2.1	2.3	2.1	2.1	5.15	5.04	4.79	3.92	4.72
Average	2.0	2.0	2.3	2.1		4.10	4.19	4.37	3.65	
LSD at 5% for :										
Varieties	0.6								0.183	
Weed Control	1.1								0.360	
Interaction	NS								0.478	
	Biological yield (t ha $^{-1}$)					Harvest index (%)				
Control	9.00	7.95	8.80	7.74	8.38	35.2	35.3	36.1	31.1	34.4
Bentazon	12.75	15.89	11.33	16.30	14.06	30.3	24.3	36.7	26.1	29.4
Benta+ GA_3	18.68	16.20	18.02	13.31	16.55	23.7	32.6	26.7	29.7	28.2
Florasulam+Flumetsulam	14.60	12.53	11.94	12.07	12.79	38.9	34.4	41.0	33.0	36.8
Floras + Flumet + GA_3	12.88	10.62	11.98	10.37	11.46	29.7	30.1	32.6	28.8	30.3
Fluroxypyr	12.89	11.64	11.00	10.88	11.60	33.5	31.6	37.9	31.7	33.7
Fluroxypyr +GA_3	10.64	12.94	12.75	9.92	11.56	33.7	34.5	39.7	36.6	36.1
Hand weeding	13.60	12.36	14.10	12.65	13.18	38.2	40.8	34.0	31.0	36.0
Average	13.13	12.52	12.49	11.66	12.57	32.9	33.0	35.6	31.0	
LSD at 5% for :										
Varieties	0.108								2.5	
Weed Control	0.213								4.8	
Interaction	0.281								NS	

Gem:Gemmeiza, Floras: Florasulam, Flumet: Flumetsulam, GA_3: Gibberelic acid

Flumetsulam herbicide recorded the highest grain yield relative to the other herbicides and was statistically at par with hand weeding treatment (Table 4). Similar findings were reported by Abbas *et al.* [3], Alda *et al.* [13], Chaudhary *et al.* [14] and El-Metwally and Saudy [44].

Concerning the addition of GA_3 tankmixture with herbicides, data in Table 4 revealed that there is synergistic effect between the growth regulator GA_3 and Bentazon or Fluroxypyr herbicides where the grain yield per hectare was increased by 20.1 and 12.3% compared to each herbicide applied alone, respectively. These increments may be attributed to the positive hormonal roles of Gibberillic acid [52] on wheat plants and to improve the efficacy control of the herbicides on weeds (Tables 1 and 2). Gibberellic acid (GA_3) facilitates cell elongation in different organs and tissues throughout plant growth and development [53]. Similar findings were reported by Sharara *et al.* [10] and Tagour *et al.* [23]. Zhang *et al.* [54] reported that some plant growth regulators can accelerate the absorption and translocation of herbicides in weeds when they are used together with herbicides and improve the effect of weed control [55]. Sharara *et al.* [10] found that the application of prometryn in tank mixture with benzoic acid at the concentration of 720 g/ha resulted in effective-weed control and yield as applying the herbicide alone at the recommended dose, without apparent toxicity on lentil plants. On the other hand, there was antagonistic effect between tankmixture of GA_3 and Florasulam+ Flumetsulam on wheat grain yield where addition GA_3 to the herbicide resulted in a reduction in the grain yield by 21.6% relative to the herbicide alone.

Concerning the interaction effect between wheat varieties and weed control management, the results in Table 4 demonstrated that the greatest grain yield was obtained when sowing Gemmeiza 9 variety and controlling the weeds by Florasulam+Flumetsulam herbicide which didn't differed statically with Sakha 93 *cv* under Bentazon + GA_3 or hand weeding in Gemmeiza 9. The results showed a significant interaction between the competitive ability of varieties and herbicide performance. Mennan and Zandstra [29] reported that taller wheat cultivars did not always produce the highest yields even in weed infested plots. Snaydon [56] suggested that a wheat cultivar's competitive ability may be negatively associated with potential yield. Generally taller cultivars contribute relatively more resources to the vegetative plant parts than to the grain. Mason *et al.* [34] reported that the tallness and early heading and maturity were related to increased grain yield at the highest weed level. Greater spikes/m^2, tallness and early heading were associated with reduced weed biomass, depending on weed level. Principal component analysis (PCA) revealed that height accounted for a small amount of variation in low weed environments, yet was more important as weed pressure increased. Regarding the harvest index criteria data in Table 4 indicated that Sakha 94 had the highest harvest index while Giza 168 was the lowest one. Controlling the weeds grown associated with wheat plants with Florasulam+Flumetsulam herbicide or hand weeding led to improve the harvest index as mentioned in Table 4. Young *et al.* [57] reported that weed management practices significantly affect total number of tillers, 1000 grain weight and harvest index.

CONCLUSION

- There is synergistic and antagonistic effect between the growth regulator GA_3 and the herbicides on weeds and wheat yield depend on the weed specie and the herbicide.
- The greatest grain yield was obtained when sowing Gemmeiza 9 variety and controlling the weeds by Florasulam+Flumetsulam herbicide which didn't differed statically with Sakha 93 cv under Bentazon+ GA_3 or hand weeding in Gemmeiza 9 variety.

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