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WEED CONTROL IN FIELD GROWN TUBEROSES (*Polianthes tuberosa, L.* .) CV. 'DOUBLE', IN THE WESTERN REGION ARID ZONE OF SAUDI ARABIA: B. MUTUAL INTERACTIVE EFFECTS OF IRRIGATION FREQUENCIES, MANUAL HAND WEEDING, AND HERBICIDES ON WEED POPULATION DENSITY, WEED GROWTH PERFORMANCES AND TUBEROSE CUT FLOWER YIELD

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Abstract: A Split-Split-Plot field investigation, with four replicates, in Complete Randomized Block Design, was performed to confront weed competition problems, in field grown tuberoses, under the Saudi Arabian Western Region Arid Zone environmental conditions. Integrated weed management practices, under different irrigation frequency regimes, yielded highly significant two and three way interactions, during the 2001/02 and 2002/03 growing seasons.

Plots subjected to hand weeding every 4 or 8 weeks and irrigated every 8 days, exhibited noticeable reductions in weed population densities, fresh and dry weights, in comparison with unweeded controls and/or those weeded every 12 weeks. Plots weeded frequently every 4 weeks and irrigated every 6 or 8 days revealed the lowest weed-water use efficiency, estimated on dry weight basis, when compared to unweeded controls and irrigated every 2 or 4 days. Plots subjected to hand weeding every 4 weeks and irrigated every 8 days showed the highest weed control efficiency, in comparison with unweeded controls or those weeded every 12 weeks and irrigated every 8 days.

Plots treated with glyphosate or pendimethalin plus glyphosate and watered every 2 or 4 days, immensely reduced weed density, fresh and dry weights, when compared to untreated controls or those treated with pendimethalin and irrigated every 2 or 4 days. Plots treated with pendimethalin alone or pendimethalin plus glyphosate and frequently watered every 6 or 8 days produced lower weed density, fresh and dry weights, than plots treated with glyphosate or lefted as untreated controls and irrigated every 6 or 8 days. While glyphosate preferred functioning under wet moist conditions, Pendimethalin noticeably favored functioning on the drier side and stressful conditions. Plots treated with Pendimethalin plus glyphosate, at all irrigation frequency levels considerably lowered weed-water use efficiencies, estimated on dry weight basis, when compared to those untreated controls at almost all levels of irrigation frequencies. Plots treated with Pendimethalin plus glyphosate and irrigated either every 2 or every 4 days recorded the highest weed control efficiency, in comparison with the untreated controls. Pendimethalin treatment alone under stressful conditions (irrigation every 8 days) exhibited appreciably high weed control efficiency performances, in comparison to its effects under high available moisture and irrigation every 2 days, in both seasons.

Results indicated that, the most notable effects, for the highest weed population density, heaviest weed fresh and dry weights, were expressed by unweeded untouched untreated controls or untreated controls weeded every 12 weeks. However, plots received Pendimethalin plus glyphosate and subjected to weeding every 4 or 8 weeks revealed noticeably contrasting effects. The existence of Pendimethalin and glyphosate together in combination in one single treatment alone or along weeding every 4 or 8 weeks greatly increased weed control efficiency, when compared to other treatments.

Unweeded controls or even those weeded every 12 weeks and treated with Pendimethalin herbicide or left untreated at all and irrigated frequently every 2 days noticeably encouraged emergence of high weed population densities and profusion, prosperous in fresh and dry weights. Whereas, unweeded controls receiving pendimethalin plus glyphosate or weeded every 4 or 8 weeks and treated with glyphosate alone or Pendimethalin plus glyphosate demonstrated the opposite performances.

Plots weeded every 4 or 8 weeks and treated with pendimethalin plus glyphosate at any level of irrigation exhibited the lowest water use efficiency, on dry weight basis. Plots subjected to frequent hand weeding every 4 or 8 weeks and treated with pendimethalin plus glyphosate under 2, or 4 days of irrigation revealed the highest weed control efficiency, in comparison to plots lefted unweeded or weeded every 12 weeks and treated with pendimethalin.

Tuberose cut flower yield was considerably influenced by the mutual interactive effects of the second and third order interactions; irrigation frequencies x hand weeding; irrigation frequencies x herbicides; manual hand weeding x herbicides and irrigation frequencies x hand weeding x herbicides.

Additional Index Words: Tuberose, Polianthes tuberosa, L., Interactions, Irrigation Frequency, Hand Weeding, Herbicides, Weeds, Pendimethalin, Glyphosate, Water Use Efficiency, Weed Control Efficiency.

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Introduction

Tuberose (*Polianthes tuberosa, L*), Family *Agavaceae*, was enthusiastically introduced into the Saudi Arabian Arid Zone Area of the Western Region, as a new floricultural crop, in the last decade. The main goal and target was adaptation, acclimatization and diversifying ornamental floricultural crops, in the region, and also minimizing cut flower import from Egypt, Lebanon and neighboring countries (El-Naggar and Byari, 1999 a, b, c, and d). Successful establishment, adaptation and acclimatization were accomplished, and comprehensive program(s) for amelioration and enhancement were initiated, particularly when the Saudi community and public highly recognized, acknowledged and venerated tuberose flowers. The Saudi Arabian flower shop owners, whole sale businessmen and common peoples were highly fascinated and enthralled with tuberose flower scent and aromatic fragrance, which conspicuously intensify, especially, at night times. The western region arid zone of Saudi Arabia is characterized by harsh environmental conditions and water shed problems. Depletion of ground water, drought and high cost of water desalinization in Saudi Arabia mandate developing research program(s) for water conservation and rationalization of irrigation water in field grown tuberoses. Many researchers and scientists ascertained that high levels of irrigation water is extremely beneficial for cut flower production and bulb growth and development, in numerous bulbous ornamentals (Papaneck, 1992; El-Naggar and Nassar, 1994; Dandria *et al.,* 1996; Suda *et al.,*1996; and Halepyati *et al.,* 2002). However, Hoffman, 1988, Armellina and Zimdahl 1989; Singh *et al*., 2002; Mirabelli *et al*., 2005; Borowczak *et al*., 2005; and Patel *et al*., 2005, reported that, increasing watering levels or irrigation frequencies promote weed growth and development and considerably hasten its intensity, which, subsequently, reduce significantly crop yield. Nevertheless, among constrains and obstacles threatening and challenging high productivity of cut flowers and bulbs, in field grown tuberoses, was weed growth and infestation, particularly under furrow irrigation system (Sutton *et al.,* 2007). Weed growth, competition and interference with such a crop result in great reduction and deterioration in crop yield. Reduction in crop yields due to weeds result from their multiferous ways of interfering with crop growth and crop culture. Weeds compete with crops for one or more plant growth factors, such as mineral nutrients, water, solar energy and space and they considerably encumber crop cultivation operations (Zimdahl 2004). Therefore, integrated weed management, in field-grown tuberoses was substantially vital, and Strategic agrochemical approaches were compulsory, to surmount weed competition problems.

Traditionally, weeds are generally controlled by mechanical means, such as cultivation and hand hoeing or even manual hand weeding. However, mechanical weeding was proven very efficient in controlling weeds in different flowering bulb plantations according to Mohanty *et al*, 2002; and Panwar *et al*, 2005 on tuberoses; Chahal *et al*, 1994; Widaryanto *et al*, 1997; and Cheong *et al*, 2000 on gladioli; Pennucci, 2000 on German Iris; and Bullitta *et al*., 1996, on Crocus. Nevertheless, mechanical ways, for controlling weeds, on the other hand, are arduous, laborious, and backbreakingly strenuous, which subsequently leads to immense increase in production costs (Ramirez *et al.,* 2007). Nonetheless, the use of chemical herbicides (preemergence and/or postemergence) for weeding solely and/or as an ancillary approach(s), to mechanical means, could reduce labor by 61.5 to 87.7 %, which in turn decrease weeding costs by 40.2 to 70.9 %, when compared to manual weeding. It could also reduce water & soil losses and surface water evaporation, creating good ecological environment for growth according to JianRong, 2004.

This investigation was undertaken to evaluate weed population density, growth performances and tuberose cut flower yield as influenced by the mutual interactive effects, among irrigation frequencies, hand weeding and herbicidal applications, in field grown tuberoses, at Hada Al'Sham's Agricultural Experiment Station, Macca AL-Mokaramah area, KSA.

Materials and Methods

The concurrent investigation was conducted at Hada AL-Sham's Agricultural Experimental Station, for Ornamental Plants Researches and Indoor Plant Propagation, of King Abdul-Aziz University, geographically located in Hada AL-Sham's valley, 80 Km North East the City of Jeddah (Makkah AL-Mokaramah vicinity), during the growing seasons of 2001/2002, 2002/2003.

Plant Materials

Tuberose bulbs (*Polianthes tuberosa, L.*) cv. "Double", or the pearl, were imported as clumps, from Abaadeia, Warak-Giza, Republic Arab of Egypt. Clumps were individually divided by hand to either bulbs or bulblets with all possible sizes and weights, screened, then grouped into different categories and ultimately counted.

Investigation Insight & Experimental Layout

A main outdoor investigation was carried out to evaluate the performances of weed population growth and intensity, in field grown tuberoses, under the Western Region Arid Zone conditions, in a Horticultural Agrotechniques Strategies Project (HASP) for ameliorating tuberose, through investigating the impacts of irrigation frequencies, manual weeding, and herbicidal treatments.

The experimental design and layout was set up as split-split-plot, in complete randomized block design, in four replicates, with 1.5 x 2 meter experimental plot (experimental unit). The irrigation frequencies or watering intervals treatments (irrigation after two, four, six and eight days) were randomly assigned to the whole plots. The sub-plots, however, were, indiscriminately, assigned to the manual weeding treatments (control (no weeding), every 2, 4 and 6 weeks) and the sub-sub-plots were randomly assigned to the weed control herbicidal treatments (control, Pendimethalin, glyphosate, and Pendimethalin + glyphosate). Each experimental unit (sub-sub-plot) was planted with 24 tuberose bulbs (4 rows x 6 columns) of 3.5-4.5 cm in diameter, at distances of 25 x 30 cm.

Experimental Site Preparations and Bulb Planting

Soil was deeply ploughed, using tractors, in all directions, harrowed, cleaned from rocks, evenly mannured with compost as a basic dose at the rate of 10 ton/ha, irrigated, and then subjected to solarization, for several days. These sequential operations were repeated several times, to initially, infertile the poor soil with a base organic matter, and to enhance its structure. The experimental site was planned and designed, according to the preplanned layout of the intended investigation, to include experimental plots of 1.5 x 2 meter each. All experimental plots were treated with Carpofuran granules against termites (the area is colonialized with termite colonies), which dangerously attack any tender or succulent materials, in the area, such as roots, bulbs, tubers…etc.

Tuberose bulbs ranging sizes (3.5 – 4.5 cm) in diameter, and 38-55 g average weights, were planted on April 28th, 2001/2002, and April 30th in the 2002/2003, growing seasons, respectively. Bulbs were planted according to the anticipated statistical design and layout of the split-split-plot design. All experimental plots were fertilized with the 5-10-5 complete fertilizer, at the rate of 200 kg/ha, in two split doses. The first dose was given 45 days after planting, while the second one was applied after 90 days, in both seasons.

Experimental Site Soil Characterizations

Several laboratory and field tests and studies were conducted at the field experimental site, including soil mechanical, chemical analyses and determination of field capacity.

Soil Mechanical Analysis:

Three representative samples were collected from each soil depth (0-15 and 15-30 cm.) out of thirty experimental site locations, at the experimental farm, to characterize and determine soil texture of the field sites. These three samples per depth were pooled together for each location (thirty location). Samples/depth of these thirty locations were evenly pooled inclusively to yield a homogeneous representative sample for each depth. Each depth sample soil texture, at the experimental site, was found to be loamy sand, using the hydrometer method (Jackson, 1973).

Table (1): Soil Mechanical Analysis of Tuberose Experimental Site.

Depth	Coarse Sand(%)	Medium Sand(%)	Fine Sand(%)	Silt (%)	Clay (%)	Texture
0-15	56-70	00-14	06-10	1-11	8-40	Loamy Sand
15-30	00-53	10-41	15-45	13-90	7-24	Loamy Sand

Soil Chemical Analysis

Soil chemical analyses for tuberose experimental site were also conducted for Cations and anions, nitrogen, phosphorus, potassium and organic matter (Table 2, and 3). Soil chemical analyses were performed following Jackson 1973.

Table (2): Soil Chemical Analyses for Tuberose Experimental Site (meq/l)

Depth (cm)	Cations (meq /l)				Anions (meq /l)				E.C mm/cm	pH
	K	Na	Ca	Mg	SO4	Cl-	HCO3-	CO3--		
0-15	0.72	6.14	1.82	0.67	2.71	70.56	16.11	0.20	2.77	8.25
15-30	0.72	8.22	2.6	0.93	2.91	77.7	15.41	0.00	3.12	7.80

Table (3): Nitrogen, Phosphorus and Potassium Concentration (mg/kg), and Organic Matter (%), at Tuberose Experimental Site

Depth (cm)	Nitrogen	Phosphorus	Potassium	Organic Matter (%)
0-15	0.32	0.13	2.50	0.479
15-30	0.30	0.11	2.50	0.883

Field Capacity at Tuberose Experimental Site

Field capacity was determined, in tuberose experimental site using a field plot, well irrigated through flood irrigation, covered with weed to eliminate evaporation, and left out for 48 hours. The percentage of moisture content were estimated in two experimental locations using three samples per location, to yield the field capacity in both locations as 15.7 and 16.32, respectively. Therefore, the field capacity in tuberose experimental site was estimated to be 16.00%. However, calculations were performed to estimate the amount of water required, each time for irrigation, to allow soil to reach the field capacity in the whole unit as 3.00 m^3 in the experiment.

Experimental Procedures and Treatment Applications

Irrigation Frequencies

Four 10-ton capacity tanks were installed and devoted for the execution of this investigation, one tank per two replicates (the experiment included four replicates). These four tanks were always maintained full of available water all times for the irrigation water treatments. A-4.5 horsepower water pump was also installed to deliver water in main, sub-main, and sub-sub-main pipes and tubes, in six-par active pressure, to the experimental plots, from these tanks. Irrigation treatments; after two, four, six and eight days were planned as to supply certain amount of water, through control points and gauges meters, calculated to reach the field capacity, for each specified experimental whole unit, assuming that the depth of the root zone distribution of tuberose plant is 30 cm depth. Each experimental whole plot in the experiment, included 16 experimental units (plots), which occupied an area of 48 m^2, required 3.00 m^3 of irrigation water, supplied by the fiberglass tanks, and were equivalent to 3000 liter/whole plot. Nevertheless, irrigation water quantities and amount, supplied through the tank suppliers and according to the measuring meter gauges readings, for weed population study, which took 180 days until harvesting weeds and recording data, consumed were 11.25, 5.63, 3.75 and 2.81 cubic meter of water per whole plot, during the 180 days, respectively, in correspondence with irrigation every 2, 4, 6 and 8 days in sequence. However, irrigational treatments scheduling was started after two months from the initial bulb planting. Tuberose bulbs were, however, watered, during this period, through furrow irrigation from bulb planting until complete sprouting and plant establishment took place.

Weed Control Treatments
Manual hand weeding and hoeing

Several farm workers performed manual hand weeding and hoeing operations, according to preplanned schedule and timetable, for the assigned sub-plot treatments; control or check (sub-plots left unweeded), weeded every four, eight and twelve weeks.

Pendimethalin

Pendimethalin, (N- (1-ethylpropyl)-3,4-dimethyl-2, 6-dinitro-benzeneamine (C_{13} H_{19} N_3 O_4)), is manufactured by BASF Corporation, Agricultural Products Group, Research Triangle Park, NC 27709, USA. It was bought from an agricultural establishment in Jeddah, Saudi Arabia with the trade name Pendulum® WDG (water dispersible granules), 60 % active ingredients. It was used at the rate of 2.0 kg a. i. /ha, as a dry flowable formulation (0.128 kg Pendimethalin/ 10 Liter water to cover area of 384 m^2 as specified and labeled sub-sub-plots for treatments), five days after bulb planting. Pendimethalin granules were properly mixed with about 5.00 liter of water and this diluted mixture was slowly added into a Ten-liter high-pressure hand sprayer tank. However, the remainder of the tank was carefully filled with water, with continuous agitation. Nonetheless, during Pendimethalin application, agitation was occasionally performed to ensure excellent mixing. Moreover, thorough agitation was also performed to resuspend the mixture before spraying is resumed, when the spray mixture was allowed to settle, during indicating the labeled specified sub-sub-plots, according to the experimental design and layout.

Glyphosate

Glyphosate, N-(Phosphonomethyl) glycine, C_3 H_8 NO_5 P, or Round up Ultra Max (60 % WSC) was used in this investigation. It is manufactured by Monsanto, Co., (800 N Lindbergh Blvd. St. Louis, Mo 63167, USA). It is used at the rate of 1.0 % a. i. /ha, in this experiment, and applied 60 days from bulb planting, as post emergence treatment, to the assigned sub-sub plots. However, dry ammonium sulphate at the rate of 2.0 % (by weight) was added to the spray solution to improve water quality of Hada Al-Sham.

Pendimethalin + Glyphosate

According to experimental design and the layout, sub-sub-plots assigned for the combined treatments of Pendimethalin and glyphosate were treated with both herbicides as preemergence Pendimethalin, 2 kg a. i. /ha, (5 days from planting) and round up as postemergence, 1.0 a.i % /ha, (two months from planting).

Measurements and Data Collection

Weed Growth Population Parameters & Measurements and Weed Control Efficiency

Data measurements were recorded for weeds in the different experimental sub-sub-plots in both seasons, 180 days after tuberose planting. Scale of Abundance: numerical abundance or frequency scale of the different infested weeds was performed according to (ZMSPS); The Zurich-Montpellier School of Phyto-Sosiology (Braun-Blanquet, 1964). This scale depends on actual field observation and visual rating of weed frequency of abundance and prevalence, in field grown tuberoses, particularly those of untreated sub-sub-plots; 20 % existence of a specific weed species was given the symbol * (very low), ** (low) represent 40 %, *** (medium) represent 60 %, **** (high) represent 80 %, and ***** (very high) represent 100 % abundance and/or existence. Weed intensity (density) or weed count, with careful hand or manual pulling, was performed per sub-sub-plots (3.0 m^{-1}) for all experimental units. Weeds of each experimental sub-sub-plots were freshly weighed in kg. Weed dry weights were also performed. Water use efficiencies were also calculated based on either number of weeds produced or unit dry weight per sub-sub-plot per cubic meter of water. Efficiency of weed control was determined according to the formula WCE (%)= 100 – (A/B * 100), where A= dry weight of weeds in a treated sub-sub-polt, and B= dry weight of weeds in the untreated controls, according to Balah *et al*., 2006. At the end of the flowering season, cut flower yield produced was surveyed and subjected to statistical analyses.

Statistical analyses

Statistical analyses were performed using the General linear Model (*GLM*) procedure, along with the regular analysis of variance, SAS computer package, and MSTAT computer Program (SAS, 1978; Steel and Torrey, 1980; and Freed *et al*., 1985). Orthogonal polynomial regression analyses, for the equally spaced categories factor, using polynomial coefficients (Gomez and Gomez, 1984), were performed to describe response curves (linear, quadratic and cubic) of weeds different traits, using the Sigma Plot Scientific Graphing System (SPSGS).

Results and Discussions

The Two Way Interactions

✽ Irrigation Frequency x Manual Hand Weeding

Weed Density, Fresh and Dry Weights

The different irrigation frequency treatments and the manual hand weeding practices performed, in field grown tuberoses, interacted mutually together and yielded highly significant effects, on weed population density, fresh and dry weights, in the two growing seasons (Table 4 and Figure 1).

Unweeded controls or plots weeded frequently every 12 weeks and irrigated frequently every two days registered the highest weed population density, the highest total weed fresh and dry weights, in both seasons. However, plots subjected to hand weeding every 4 or 8 weeks and frequently irrigated every 8 days exhibited strong contrasting effects, for population intensity, fresh and dry weights, for emerging weeds, in the two growing seasons. The strong impacts of irrigation frequency every two days, in plots weeded every 12 weeks or the unweeded control may be attributed to ideal environment for weed growth and florishment; high available soil moisture, more available nutrient, space and light and no restriction except that interruptions of manual weeding every 12 weeks. Conversely, the immense reduction in population intensity as well as its fresh and dry weights, in plots receiving 4 or 8 weeks hand weeding and irrigated every 8 days, perhaps, might be due to severe soil water stresses, imposed by long intervals for irrigation, particularly under such harsh environment, which subsequently accompanied by poor supply of available nutrient to the emerging weeds, from the soil. Above and beyond, the synergistic influences of the imposed manual hand weeding every 4 and/or 8 weeks perhaps augmented these weed-minimizing effects.

Water Use efficiencies

Water use efficiency, estimated as weed number emerged in a sub-sub-plot by one single cubic meter of water (Table 4, and Figure 2), revealed highly significant differences, as influenced by irrigation frequency treatments and manual hand weeding, in both seasons. Unweeded sub-sub-plots, irrigated every 6 or 8 days, or even those irrigated every 8 days and hand weeded every 12 weeks, displayed the highest water use efficiencies (84.63, 92.48 and 83.83) and (75.07, 86.27 and 75.3), in the two growing seasons respectively. On the other hands, sub-sub-plots weeded every 4 weeks and irrigated every 2 days yielded the lowest water use efficiencies (24.11 and 31.56), in both seasons, correspondingly. Obviously, untouched unweeded sub-sub-plots irrigated every 6 or 8 days or even those weeded every 12 weeks and irrigated every 8 days were undergoing inconvenient stressful conditions. Subsequently, weeds were, perhaps, enforced to flower and to reproduce, dispersing more seeds to increase in number, taking advantages of each single cubic meter of water supplied, under these hectic conditions. Contrastingly, sub-sub-plots weeded frequently every 4 weeks, and irrigated even every 2 days, might had the chance to consume

less water because of low weed emergence, resulting in minimizing water use efficiency.

Water use efficiencies, estimated on the basis of unit dry weight produced by weeds in a sub-sub-plot by one single cubic meter of water (Table 4 and Figure 2), also showed immense impacts, as influenced by both factors. Unweeded controls, irrigated every 2 or 4 days produced the highest water use efficiencies, on dry weight basis, in both seasons, in comparison to sub-sub-plots weeded frequently every 4 weeks and irrigated every 6 or 8 days. Certainly, weeds emerging in untouched unweeded sub-sub-plots, where high available water and soil moisture provided through frequent irrigation every 2 or 4 days, besides available nutrient, space and solar energy, exploited these conditions to intensify photosynthesis, accumulating more dry matter and building up extra biomass, subsequently maximizing water use efficiency. Conversely, weeding every 4 weeks performed synergistically together with water stress conditions imposed by frequent irrigation every 6 or 8 days, minimizing water use efficiency, on dry weight basis, in the two growing seasons.

Weed Control Efficiency

Irrigation frequency treatments and manual hand weeding interacted mutually and noticeably affected weed control efficiencies, in both seasons (Table 4 and Figure 2). The highest weed control efficiency was recorded in sub-sub-plots subjected to hand weeding every 4 weeks and irrigated every 8 days (60 %), followed by hand weeding every 4 weeks and irrigated every 4 days (49.73 %), followed by weeding every 8 weeks and irrigated every 2 days (51.34 %), in the first growing season. However, the same treatments, in sequence, also registered 48.99, 44.00, and 35.39 % for weed control efficiency, in the second growing season. Divergently, sub-sub-plots subjected to hand weeding every 12 weeks and watered every 8 days (19.30 and 16.43 %) or the untreated controls (0.0) showed the lowest weed control efficiencies, in both seasons, respectively. High percentages of weed control efficiencies, in both seasons, might be attributed to the strong impacts of frequent weeding on relatively short period of time (4 weeks), particularly when irrigated every 4 or 8 days. In contrast, unweeded controls or even those weeded every 12 weeks, and irrigated every 8 days, where minimal elimination of weeds, was performed, would subsequently register the lowest efficiency for weed control.

✿ Irrigation Frequency x Herbicidal Treatments

Weed Density, Fresh and Dry Weights

The different irrigation frequency treatments interacted mutually with the different herbicidal applications, yielding highly significant performances, for weed density, fresh and dry weights, in both seasons (Table 4 and Figure 3). Data illustrated on Figure 3, evidently show that, sub-sub-plots lefted as controls or those treated with Pendimethalin and irrigated every 2 or 4 days, resulted in the greatest weed population density, fresh and dry weights, in comparison with sub-sub-plots treated with glyphosate or Pendimethalin plus glyphosate and irrigated every 2 or 4 days, in both seasons. On the other hand, sub-sub-plots treated with glyphosate or lefted untouched as controls and irrigated every 8 days produced higher weed density, fresh and dry weights, in comparison with sub-sub-plots treated with Pendimethalin or Pendimethalin plus glyphosate and irrigated every 8 days, in both seasons. These noticeable different performances, for weed density, fresh and dry weights, due to irrigation frequencies and herbicides interactive effects, may be accredited to the autosensetively selective efficacy and functionality of the different herbicides under wide range of irrigation frequency treatments. While glyphosate preferred functioning under wet moist conditions, Pendimethalin noticeably favored functioning on the drier side and stressful conditions. Apparently, glyphosate functions better and was more effective, under high available soil moisture provided by 2 or 4 days irrigation, where Pendimethalin was probably functioning less effectively favoring stress conditions.. On the other hand, under soil water stresses imposed by irrigation every 8 days, glyphosate appeared to be relatively inactive in comparison to Pendimethalin, which exhibited high performances and effectiveness. ChaoXian *et al.*, 1999, provided evidence and found that the effect of glyphosate on the shikimate pathway enzyme was considerably reduced under moisture stresses and dry conditions. Moreover, Sahid *et al.*, 1996; Adkins *et al.*, 1998; and Tworkoski *et al.*, 1998, reported that glyphosate, in different rates, was immensely effective in reducing weed density, fresh weight and accumulated dry biomass, under highly frequent irrigations, and noticeably less or not effective under dry or stress conditions. However, concerning Pendimethalin efficacy and behavior, Vouzounis and Americanos, 1992, concluded that, when soil moisture content was reduced from 15 % to only 2 %, the rate of Pendimethalin degradation was significantly retarded. Yadav *et al.*, 1993, also found that, 63.50, 75.20, and 88.00 % reductions in the initial concentration of Pendimethalin

applied to wheat were observed with 2, 4, and 6 irrigation events, respectively. Furthermore, Yadave *et al*., 1995, also reported that Pendimethalin works better under dry conditions, and adverse residual effects were more prevalent when only two irrigations were applied as compared to four or six irrigations. Singh *et al*., 2002, at Haryana-India, reported that, weed density and weed dry weight were highest under weedy control where 4 irrigations were given. However, the lowest weed count and dry weight of weeds were obtained in plots where Pendimethalin at 1.5 Kg/ha was applied and received only 2 irrigations.

Water Use efficiencies

Water use efficiencies, estimated as weed count/sub-sub-plot/m^3 water, were greatly influenced by the mutual interactive effects of irrigation frequency treatments and herbicides, in both seasons (Table 4 and Figure 4). Weeds emerged in untouched untreated controls and irrigated frequently every 6 or 8 days were considerably higher, in the water use efficiency index, as produced by one single cubic meter of water, in comparison to those emerged in the Pendimethalin plus glyphosate treated sub-sub-plots and irrigated every 2 or 4 days. Obviously, weeds emerged in the untreated control and irrigated every 6 or eight days were increased under such circumstances, increasing water use efficiency indices, in both seasons. However, those emerged under 2 or 4 irrigation regimes, Pendimethalin plus glyphosate treatment, herein, reduced weed count and number, resulting in reducing weed control efficiency, in these cases. Tanji and Karrou, 1992, found that, weed control by glyphosate and 2,4-D, reduced the total water used and increased the total WUE, in both seasons.

Water use efficiencies, in field grown tuberoses, estimated on dry weight basis, were significantly influenced by the mutual interactive effects of irrigation frequency and herbicides treatments, in both seasons (Table 4 and Figure 4). Untreated controls at almost all levels of irrigation frequencies were considerably higher, in water use efficiencies, than those treated with Pendimethalin plus glyphosate, at all irrigation frequency levels, in the two growing seasons. These performances might be due to the strong impacts of Pendimethalin plus glyphosate, which result in minimal weed's water use efficiencies, in both seasons, in comparison to the untreated controls.

Weed Control Efficiency

Data of Table 4 and Figure 4, revealed highly significant impacts on weed control efficiency, in both seasons, due to the interactive effects of irrigation frequencies

and different herbicidal treatments. Apparently, sub-sub-plots treated with Pendimethalin plus glyphosate and irrigated either every 2 or every 4 days recorded the highest weed control efficiency, in comparison with the untreated controls. Glyphosate treatment alone, irrigated every 2 or 4 days showed considerably higher weed control efficiency in comparison to plots treated with Pendimethalin alone and irrigated every 2 or 4 days. However, Pendimethalin treatment alone under stressful conditions (irrigation every 8 days) exhibited appreciable weed control efficiency performances, in comparison to its effects under high available moisture and irrigation every 2 days, in both seasons. Results obtained by Sahid *et al*., 1996; Adkins *et al*., 1998; Tworkoski *et al*., 1998; ChaoXian *et al*., 1999; Vouzounis and Americanos, 1992; Yadav *et al*., 1993; and 1995, are in great support with our findings.

✹ Manual Hand Weeding x Herbicidal Treatments

Weed Density, Fresh and Dry Weights

Manual hand weeding and herbicidal application treatments interacted together yielding highly significant interactions for weed intensity and fresh and dry weights, in both seasons (Table4 and Figure 5). Results, and statistical analyses, illustrated on Figure (5) indicated that, the most notable effects, for the highest weed population density, heaviest fresh and dry weights, were expressed by unweeded untouched untreated controls or untreated controls weeded every 12 weeks. However, sub-sub-plots received Pendimethalin plus glyphosate and subjected to weeding every 4 or 8 weeks revealed noticeably contrasting effects, in both seasons. Many scientists reported that, frequent hand weeding supplemented with Pendimethalin and/or glyphosate drastically reduced weed intensity and fresh and dry weights, in field grown gladiolus (Chahal *et al.,* 1994); sweet potatoes (unamma *et al.,* 1989); onions (Manisha *et al.,* 2005; Khokhar *et al.*, 2006; Nargis *et al*., 2006; and Murthy *et al*., 2007); and garlic (Mehmood *et al*., 2007).

Water Use efficiencies

Manual weeding and herbicide treatments undergone strong reciprocal impacts affecting weed-water use efficiency, estimated as weed count/sub-sub-plot/cubic meter of irrigation water supplied, considerably, in both seasons (Table 4 and Figure 6). Sub-sub-plots subjected to hand weeding every 4 or 8 weeks and treated with Pendimethalin plus glyphosate recorded the lowest weed-water use efficiency, in comparison to the untreated controls. Apparently, frequent hand weeding every 4 or 8 weeks acted synergistically together with

Pendimethalin plus glyphosate, yielding the minimal weed-water use efficiency, if compared to the untreated controls. Weed-water use efficiency, estimated on dry weight basis, also exhibited noticeable responses to the mutual interactive effects. Again, plots treated with Pendimethalin plus glyphosate and subjected to frequent hand weeding every 4 or 8 weeks showed the lowest weed-water use efficiencies, in comparison to untreated controls or untreated control but weeded every 12 weeks. Verma and Srivastava, 1989, found that, hand hoeing and chemical herbicide (1 Kg 2, 4-D/ha postemergence) were superior to the unweeded control, in term of WUE. Anureet and Singh, 2005, also reported that WUE was higher under both weed control treatments (hand weeding and atrazine at 0.5 Kg a. i application), compared with the weedy control.

Weed Control Efficiency

The mutual reciprocal effects of hand weeding and herbicides, revealed highly significant impacts on weed control efficiency, in both seasons. Evidently, the existence of Pendimethalin and glyphosate together in combination in one single treatment greatly increased weed control efficiency, in the two growing seasons. Similar results were obtained by Unamma *et al*., 1989; Naik *et al*., 2004; Manisha *et al*., 2005; Khokhar *et al*., 2006; Ghadage *et al*., 2007; Mehmood *et al.,* 2007; and Murthy et al., 2007.

The Three Way Interaction

❁ Irrigation Frequency x Manual Hand Weeding x Herbicides

Weed Density, Fresh and Dry Weights

Irrigation frequency treatments, manual hand weeding practices and the different herbicide applications, interacted reciprocally and mutually together, yielding noticeable performances for weed population intensity, fresh and dry weights, in both seasons (Table 4 and Figure 7). The most remarkable apparent performances for all weed anticipated parameters, in both seasons, were clearly illustrated on Figure (7). Unweeded controls or even those weeded every 12 weeks and treated with Pendimethalin herbicide or left untreated at all and irrigated frequently every 2 days emerged high weed population densities and profusion, prosperous in fresh and dry weights. Whereas, unweeded controls receiving Pendimethalin plus glyphosate or weeded every 4 or 8 weeks and treated with glyphosate or Pendimethalin plus glyphosate demonstrated the opposite performances. It is worthwhile reporting that, sub-sub-plots subjected to hand weeding every 4 or even 8 weeks and treated with either Pendimethalin or Pendimethalin

plus glyphosate and irrigated every 8 days revealed great reduction in weed density, as well as fresh and dry weights, in both seasons. These results are well deduced and interpreted previously. However, Thanki and Patel, 2005, at Maharashtra-India, reported that, applications of 0.8 Irrigation Water per Consumptive Pane Evaporation (IW/CPE), plus pendimethaline at a rate of 0.75 Kg/ha plus hand weeding at 50 days after planting, significantly controlled weeds, in field grown garlic, and enormously reduced weed population density and dry weight.

Water Use efficiencies

Water use efficiency, which was estimated based on number of emerged weeds/sub-sub-plot/cubic meter of water, was significantly affected by the reciprocal interactive effects of the three involved factors (Table 4 and Figure 8). Data illustrated on Figure 8, indicated that, untreated unweeded controls, which irrigated every 2, 6, and 8 days, or those unweeded controls treated with Pendimethalin or weeded plots every 8 weeks and non-treated with herbicides and irrigated every 8 days, in the first season, showed the highest weed water use efficiency. Besides, sub-sub-plots weeded every 8 and 12 weeks without any herbicide treatment and irrigated every 6 days, in the second season, also showed high weed water uses efficiency as well. However, plots weeded every 4 or 8 weeks and treated with Pendimethalin plus glyphosate and irrigated every 2 or 4 days exhibited the lowest weed water use efficiency, in both seasons. Evidently, sub-sub-plots subjected to immense frequent weeding and treated with both herbicides together and irrigated every 2 or 4 days yielded minimum weeds, consuming less water and minimizing water use efficiency for weeds, which subsequently would eventually reflected on the anticipated crop. On the other hands, unweeded untreated controls, particularly under frequent irrigations of 2, 6 or 8 days, where weeds were growing intensely consumed much water resulting in high weed-water use efficiency, which in turns would be reflected on the competing crop.

Water use efficiency, based on dry weight basis, also showed great responses to the third order interaction (Figure 8). Unweeded untreated controls or those weeded every 12 weeks and irrigated every 2, 4 or even 6 days, showed the highest weed-water use efficiency, on dry weight basis, in both seasons. In contrast, sub-sub-plots weeded every 4 or 8 weeks and treated with Pendimethalin plus glyphosate at any level of irrigation exhibited the lowest water use efficiency, on dry weight basis, in both seasons. These performances would eventually be positively reflected on the co-auxiliary cultivated crop(s). These

results, however, to great extent, support and ascertain the preceding bone.

Weed Control Efficiency

Frequent hand weeding, irrigation frequencies and herbicidal treatments interacted mutually together and resulted in great impacts on weed control efficiencies, in both seasons (Table 4 and Figure 8). It is obvious from data illustrated on Figure 8, that sub-sub-plots subjected to frequent hand weeding every 4 or 8 weeks and treated with Pendimethalin plus glyphosate under 2, 4, or 6 days of irrigation revealed the highest weed control efficiency, in comparison to plots lefted unweeded or weeded every 12 weeks and treated with Pendimethalin or lefted untreated at all under 2 or 6 days of irrigations, in both seasons. Furthermore, weeded sub-sub-plots every 4 or 8 weeks irrigated every 8 days and treated with Pendimethalin or Pendimethalin plus glyphosate, also showed the highest weed control efficiencies, in both seasons. Evidently, the strong effects of the three interacted factors, in the immense reduction and the death of weeds, were responsible for the noticeably high weed control efficacy.

Tuberose Cut Flower Yield

Irrigation Frequencies x Manual Hand Weeding

Irrigation frequencies and manual hand weeding interacted mutually together yielding highly significant interaction affecting tuberose cut flower yield, in the second growing season (Fig. 9). However, in the first growing season, statistical analysis failed to detect any significant differences for tuberose cut flower yield, although similar trend was noticed. Yield of tuberose cut flower was improved by hand weeding every 4, 8 and even 12 weeks when it was irrigated every two days. It also enhanced by weeding every 4 weeks and irrigated every 4 days, in comparison to other treatments, particularly those of unweeded controls and irrigated every 6 or 8 days. These responses might be attributed to the reduced weed competitions for nutrients, space, solar energy and soil moisture content, induced by manual hand weeding, simultaneously with frequent irrigations every 2 or 4 days, which in turns, it increased nutrients availabilities provided by high soil water contents.

Irrigation Frequencies x Herbicides

Figure 10 depicts the strong reciprocal mutual interactive effects of irrigation frequencies and the different herbicidal treatments, on tuberose cut flower yield, in the 2001/2002 and 2002/2003 growing seasons. Obviously, sub-sub-plots treated with glyphosate alone, or glyphosate plus pendimethalin and irrigated every 2 days or those treated with the combination of

pendimethalin and glyphosate and irrigated every 4 days, produced remarkably higher cut flower yield in comparison with untreated sub-sub-plots irrigated every 6 or 8 days or treated with pendimethalin, glyphosate and/or their combination and irrigated every 8 days. This behavior may be attributed to the strong influence of glyphosate and glyphosate + pendimethalin on weed elimination, reducing weed competitions, particularly under high soil water moisture content and abundance of available nutrients due to irrigation every 2 days. In contrast, although pendimethalin, glyphosate and/or their combination very efficiently controlled emerged weeds under stressful conditions and irrigation every 8 days, the lack of enough soil water moisture content and nutrients availability, due to irrigation every 8 days, were responsible for such behavior under such circumstances.

Manual Hand Weeding x Herbicides

Manual hand weeding and the different herbicidal treatments interacted mutually together yielding considerable effects on tuberose cut flower yield, in both seasons (Fig. 11). Tuberose cut flower yield was greatly increased in sub-sub-plots treated with pendimethalin plus glyphosate and weeded manually every 4, 8 and even 12 weeks. It also improved in sub-sub-plots treated with either pendimethalin alone or glyphosate alone but weeded every 4 weeks, in comparison to other treatments, particularly those untreated controls under 8 or 12 weeks of manual hand weeding. The noticeable increase in cut flower yield induced by the preceding treatments might perhaps be due to the mutual synergistic effects of pendimethalin and glyphosate in controlling weeds and eliminating its competitions, which were amplified by the different hand weeding treatments.

Irrigation Frequencies x Manual Hand Weeding x Herbicides

Figure 12 exhibits the performance of tuberose cut flower yield, as influenced by the highly significant third order interaction, of irrigation frequencies, manual hand weeding and the different herbicidal treatments, in the two growing seasons. Evidently, tuberose yield was immensely enhanced in sub-sub-plots treated by pendimethalin plus glyphosate and irrigated every 2 or 4 days and weeded every 4, 8 or 12 weeks. In contrast, sub-sub-plots untreated with any herbicidal treatment or treated with only pendimethalin and weeded every 8 or 12 weeks and subjected to irrigation every 6 or 8 days, adversely exhibited contrasting effects. The powerful synergistic effects of pendimethalin and glyphosate, when both existed together along with efficient manual weeding every 4 or 8 weeks in controlling

weed emergence, especially under abundance of water provided through irrigation every 2 or 4 days might be accountable for the remarkable performance of tuberose cut flower yield. However, the adverse effects obtained might be due to relative weed growth and soil poor in available nutrients and moisture content.

Conclusion & Recommendations

Results, reported herein, digested and assimilated through this investigation, may reveal the forthcoming and imminent conclusion, suggestions and recommendations, for the Saudi Arabian tuberose growers and farmers, in the Western Region Arid Zone, in the Kingdom, as well as similar environmental condition(s), in the neighboring area.

1- Weed competitions, in field grown tuberoses, is extremely dangerous, affecting tuberose productivities and significantly reduce the qualities. It should be controlled by whatever available mean(s).

2- If labor costs and availability are not limiting factors, water resources are relatively limited, and herbicides are not preferably desired, manual hand weeding was proven very effective in controlling weeds. Hand weeding every 4 or 8 weeks and irrigation every 6 to 8 days are recommended for minimizing weed count, fresh and dry weights, weed water use efficiencies and maximizing weed control efficacy.

3- If labor costs and availability are of great concern, water resources are somehow available, and herbicidal uses are not big deal(s) for non-edible ornamental cut flowers, herbicides should be used because of their effectiveness, in controlling weeds and for being cheap and inexpensive.

4- Whenever water resources are available, and under high moisture soil content, glyphosate, as a post emergence herbicide, should be used due to its effectiveness and functionality under these environmental conditions, for controlling weeds effectively. In contrast, under dry and stressful conditions, where water resources are somehow limited, pendimethalin, as preemergence herbicide, is preferred due to its great functionality under such circumstances, in controlling weeds, because pendimethalin is undergoing considerable degradation, under high available and plenty of irrigation water. However, under moderately common irrigation, where water resources are available, pendimethalin plus glyphosate, as pre and post emergence herbicides, registered noticeable effectiveness in controlling weeds, in field grown tuberoses.

5- Plots subjected to hand weeding every 4 or 8 weeks and treated with pendimethalin plus glyphosate, under any level of irrigation, proven very effective in controlling weeds and is preferably advisable.

6- Plots subjected to manual hand weeding every 4 or 8 weeks, and treated with pendimethalin plus glyphosate with comprehensive irrigation every 2 or 4 days, proven considerably effective in controlling weeds, recording the lowest weed-water use efficiencies and producing the heist yield of tuberose cut flowers..

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مقاومة الحشائش في الحقول المنزرعة بالصنف المجوز من نباتات التيوبروز تحت ظروف الأراضي الجافة بالمنطقة الغربية للمملكة العربية السعودية : ب. التأثيرات التفاعلية المشتركة والمتبادلة لتكرارت الرى ، المقاومة اليدوية ومبيدات الحشائش على كثافة الحشائش ، سلوكيات النمو والمحصول الزهري للتيوبروز

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أجريت تجربة حقلية بمحطة البحوث الزراعية التابعة لجامعة الملك عبد العزيز بوادي هدى الشام بمنطقة مكة المكرمة خلال موسمي 2002/2001 ، 2003/2002 م ، لدراسة التأثيرات المتبادلة بين المعاملات الأتية:

- تكرارات الرى (كل 2 ، 4 ، 6 ، 8 يوم).
- مقاومة الحشائش يدويا (بدون مقاومة ، مقاومة كل 4 ، 8 ، 12 أسبوع).
- مقاومة الحشائش بالمبيدات (بدون مبيدات ، بنديميثالين ، جلايفوسات ، بنديميثالين + جلايفوسات).

وذلك على سلوك نمو الحشائش النامية بحقول التيوبروز تحت ظروف المناطق الجافة بالمنطقة الغربية للمملكة العربية السعودية.

صممت التجربة بنظام القطع المنشقة مرتين في قطاعات كاملة العشوائية ذات أربع مكررات ، ولقد تم وضع معاملات تكررارات الرى في القطع الرئيسية (Main Plots) بينما معاملات مقاومة الحشائش يدويا فتم توزيعها عشوائيا على القطع المنشقة الأولى (Sub-Plots) ، بينما تم توزيع معاملات مقاومة الحشائش بالمبيدات على القطع المنشقة الثانية (Sub-Sub-Plots) . ولقد كانت أهم النتائج كالتالي :

أولا: التأثيرات المتبادلة بين معاملات الرى ومقاومة الحشائش يدويا.

- أظهرت المعاملة المشتركة (رى / 8 يوم + مقاومة يدوية / 4 أو 8 أسابيع) نقصا معنويا في أعداد الحشائش وأوزانها الغضة والجافة بالمقارنة بمعاملة الرى / 2 يوم + المقاومة اليدوية / 12 أسبوع أو معاملة المقارنة (بدون مقاومة يدوية).
- أعطت معاملة الرى / 2 أو 4 أيام بدون مقاومة يدوية للحشائش أعلى كفاءة حشائشية لإستخدام مياه الرى على أساس الوزن الجاف وذلك بمقارنتها بمعاملة الرى / 6 أو 8 أيام + المقاومة اليدوية / 4 أسابيع.
- نتج عن معاملة الرى / 8 أيام + المقاومة اليدوية / 4 أسابيع أعلى نسبة مئوية لكفاءة مقاومة الحشائش وذلك بمقارنتها بأى من معاملتى الرى / 8 أيام + المقاومة اليدوية / 12 أسبوع أو الرى / 8 أيام بدون مقاومة يدوية.

ثانيا : التأثيرات المتبادلة بين معاملات الرى ومقاومة الحشائش بالمبيدات.

- أظهرت المعاملتين (رى / 2 أو 4 يوم + بنديميثالين) ، (رى / 2 أو 4 أيام بدون مبيدات) أعلى كثافة عددية من الحشائش النامية ذات الوزن الغض والجاف المرتفعين وذلك بالمقارنة بأى من المعاملتين (رى / 2 أو 4 أيام + جليفوسات) ، (رى / 2 أو 4 أيام + بنديميثالين + جليفوسات).

- أعطت المعاملة (رى / 8 أيام بدون استخدام مبيدات) أعلى كثافة عددية للحشائش ذات الوزن الغض والجاف المرتفعين وذلك بالمقارنة بأى من المعاملتين (رى / 8 أيام + بنديميثالين) ، (رى / 8 أيام + بنديميثالين + جليفوسات).

- بينما فضل الجليفوسات أن يعمل بكفاءة عالية جدا تحت ظروف الرطوبة الأرضية العالية والرى المتلاحق كل يومين أو أربعة أيام ، كان للبنديميثالين خيار اخر ، فقد فضل أن يعمل بكفاءة عالية جدا تحت ظروف الجفاف والإجهاد المائي والرى على فترات متباعدة كل 6 أو 8 أيام.

- أعطت معاملات الرى / 2 ، 4 ، 6 أو 8 أيام بدون استخدام مبيدات أعلى كفاءة حشائشية لاستخدام مياه الرى بالمقارنة بمعاملة البنديميثالين + جليفوسات مع أى من مستويات الرى.

- كانت المعاملتين (رى /2 أو 4 أيام + بنديميثالين + جليفوسات) ، (رى / 2 أو 4 أيام + جليفوسات) أكثر فاعلية في مقاومة الحشائش بالمقارنة بمعاملة الرى / 2 أو 4 أيام + بنديميثالين.

- سجلت معاملة الرى / 8 أيام + بنديميثالين زيادة جوهرية في النسبة المئوية لكفاءة مقاومة الحشائش بالمقارنة بمعاملة الرى / 2 أو 4 أيام + البنديميثالين.

ثالثا : التأثيرات المتبادلة بين معاملات مقاومة الحشائش يدويا و باستخدام المبيدات.

- أعطت الحشائش التي لم تقاوم يدويا أو باستخدام المبيدات ، وأيضا معاملة المقاومة اليدوية / 12 أسبوع بدون استخدام المبيدات أعلى كثافة حشائشية وأثقل وزن غض وجاف ، بينما أظهرت معاملة المقاومة اليدوية / 4 أو 8 أسابيع + بنديميثالين + جليفوسات نتائج عكسية لذلك.

- سجلت معاملة المقاومة اليدوية / 4 أو 8 أسابيع + بنديميثالين + جليفوسات أقل كفاءة حشائشية لاستخدام مياه الرى محسوبة على أساس الغزارة العددية أو وحدة الوزن الجاف بالمقارنة بالمعاملتين (مقاومة يدوية / 12 أسبوع بدون مبيدات) أو معاملة المقارنة (بدون مقاومة يدوية أو مبيدات حشائش).

- أظهرت معاملة (بنديميثالين + جليفوسات) منفردة أو مشتركة مع المقاومة اليدوية / 4 أو 8 أسابيع أعلى كفاءة لمقاومة الحشائش في حقول التيوبروز بالمقارنة بأى من المعاملات الأخرى.

رابعا : التأثيرات المتبادلة بين معاملات الرى ، مقاومة الحشائش يدويا وباستخدام المبيدات.

- أعطت الحشائش التي لم تقاوم يدويا أو باستخدام المبيدات ، وأيضا المعاملتين (مقاومة يدوية / 12 أسبوع + بنديميثالين) ، (رى / 2 يوم بدون مقاومة يدوية ودون استخدام مبيدات) أعلى كثافة حشائشية وأثقل وزن غض وجاف.

- أظهرت معاملات (بنديميثالين + جليفوسات بدون المقاومة اليدوية) ، (مقاومة يدوية / 4 أو 8 أسابيع + جليفوسات) ، (رى / 8 أيام + مقاومة يدوية / 4 أو 8 أسبيع + بنديميثالين + جليفوسات) أقل كثافة حشائشية و أخف وزن غض وجاف.

- أعطت الحشائش التي لم تقاوم يدويا أو باستخدام المبيدات وأيضا معاملة الرى / 2 ، 4 أو 6 أيام + المقاومة اليدوية / 12 أسبوع أعلى كفاءة حشائشية لاستخدام مياه الرى ، مقدرة بالنسبة للوزن الجاف.

- أظهرت معاملة المقاومة اليدوية / 4 أو 8 أسابيع + بنديميثالين + جليفوسات تحت أى مستوى من مستويات الرى أقل كفاءة حشائشية لاستخدام مياه الرى بالنسبة للوزن الجاف.

- كانت معاملة الرى / 2 ، 4 ، أو 6 يوم + المقاومة اليدوية / 4 أو 8 أسابيع + بنديميثالين + جليفوسات أفضل المعاملات حيث أعطت أعلى كفاءة في مقاومة الحشائش وعدم نموها.

♦ سجلت الوحدات التجريبية التي عرضت لمقاومة يدوية كل 4 أو 8 أسابيع والتي عوملت بالبنديميثالين مع الجليفوسات مع رى مكثف كل 2 أو 4 أيام أعلى إنتاج للمحصول الزهري للتيوبروز وذلك بالمقارنة بوحدات تجريبية لم تقاوم بها الحشائش بالمبيدات على الإطلاق أو قومت بها الحشائش يدويا كل 12 أسبوع وعوملت بالبنديميثالين وتم ريها بمعدل كل 6 أو 8 أيام.