THE EFFECTS OF HERBICIDES ON YIELD AND QUALITY OF ONIONS

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HERBICIDES ON ONIONS

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Seven different herbicides, namely C 6313 at 1, 2, and 3 Kg (a.i.) per hectare; Tenoran at 2, 4, and 6 Kg (a.i.) per hectare; Ramrod at 4, 6, and 8 Kg (a.i.) per hectare; CP 50144 at 1, 2, and 4 Kg (a.i.) per hectare; Sindone, Stam F-34 and Prometryne each at 0.5, 1, and 1.5 Kg (a.i.) per hectare were applied as pre-emergence and post-emergence sprays on onions at the Agricultural Research and Education Center in the Beqa'a Plain, Lebanon, in 1967. Unweeded check plots were included in each replication. Phytotoxicity notes on onions and weeds were recorded. Data on onion stand, leaf length, bulb size, bulb index, yield, moisture percentage, total soluble solids, and pungency were collected.

Pre-emergence application of all the herbicides tested gave good weed control. Tenoran at 6 Kg (a.i.) per hectare and Sindone at 1.5 Kg (a.i.) per hectare gave a significant increase in the yield of onions over the unweeded check. Injury to onions occured only in plots treated with Prometryne at 1 Kg (a.i.) per hectare. Significant reductions in yield were observed from the pre-emergence applications of C 6313 at 3 Kg (a.i.) per hectare, Ramrod at 6 Kg (a.i.) per hectare, Sindone at 0.5 Kg (a.i.) per hectare, and Prometryne at 1 and 1.5 Kg (a.i.) per hectare. All rates of other herbicides tested had no significant effect on onion yield.

In the post-emergence application, weed control was not effective. With the exception of Prometryne at 1.5 Kg (a.i.) per hectare, which injured the onions and reduced the yield, the post-emergence applications of herbicides tested had no significant effects on onion yield.

None of the treatments, in both pre-emergence and post-emergence applications, had any significant effect on the stand, leaf length, bulb size, bulb index, moisture percentage, total soluble solids, or pungency of onions.

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I. INTRODUCTION

The growing and consumption of onions (Allium cepa) is world wide, and their use is neither limited to a particular climate nor associated with one nationality. They are found on most markets of the world at all seasons of the year.

In addition to their odors and flavors related to culinary use, onions are rich in food value. They may be consumed raw, cooked or in the dehydrated form. In the latter case, changes in their pungency, total soluble solids, and dry matter content may have an effect on the quality of the dehydrated product.

Lebanon produces from 40,000 to 50,000 tons of onions per year, most of which is dehydrated locally. There are three dehydration plants which produce an estimated amount of 1500 to 2000 tons of dehydrated onions per year which are exported to Europe and the United States.

Weeds are considered a major problem in onion production. Hand weeding and mechanical cultivation are becoming impractical and uneconomical. Therefore the use of selective herbicides is being considered by Lebanese growers.

To date several studies have been made on the effects of herbicides on weeds and onion yields. However, very little work has been done on the effects of herbicides on the horticultural characteristics and quality of onions. It is therefore important to study these effects under local conditions.

The purpose of this study was to evaluate the effect of seven different herbicides on the leaf length, yield, bulb size, bulb index, moisture content, total soluble solids, and pungency of onions. Observations were made also on weed phytotoxicity and weed count. Field experiments were conducted at the Agricultural Research and Education Center of the American University of Beirut during 1967, and the chemical analyses were carried out in the Agronomy Research Laboratory at the AUB during 1967 and 1968.

II. REVIEW OF LITERATURE

The use of selective herbicides in onions is a new and promising method of weed control. However, several problems pertaining to herbicidal action are still existant. Many reports have shown variable degrees of herbicide effectiveness in onions. This may be due to the chemical itself, or the method of its application. In addition, factors such as rainfall, temperature, humidity, and soil type may also have effects on the results obtained by the herbicides.

Due to the reasons mentioned above, the studies which were conducted in Lebanon and abroad on the effects of various herbicides on onions were reviewed. Very limited literature is available on the effects of herbicides used in this study on onions. Therefore, chemical and physical properties of the herbicides tested and their effects on onion yield and quality are discussed. The chemical names of all herbicides cited in this review of literature are listed alphabetically in Appendix A.

Effect of Various Herbicides on Yield and Quality of Onions

Yield

Lochman (1949) found that the pre-emergence application of chloro IPC at the rates of 6 to 8 lb per acre did not have any adverse effect on onion yields. Hernandez et al. (1950) reported that severe injury to onions planted from sets, in silt loam soils, resulted after the application of 2, 4-D, and that the yield was markedly reduced. However, on peat soils no apparent injury to onions was observed, and no significant reduction in the yield was obtained. Onions planted from seeds in a silt loam soil, which contained 2.2 percent organic matter, were also injured when 2, 4-D was applied as a pre-emergence spray. No reductions in the yield and stand of onions were observed on the peat soil.

Potassium cyanate, applied at concentrations of more than 1 to 2 percent, resulted in severe injury to onions. Diluted sprays of sulfuric acid also caused injury to onions and reduced their yields (Ahlgren _et_ _al_., 1951). Laliberte (1960) found that calcium cyanamide at the rate of 75 lb per acre plus potassium cyanate at 8 to 10 lb per acre, dissolved in 60 to 80 gallons of water and applied as a pre-emergence spray, gave higher onion yields than controls during the first two years of the trial. However, during the third year, the yield was very poor. In another experiment, Laliberte (1960) found that liquid cyanamide at the rate of 5 gallons per acre, diluted in 40 gallons of water and applied as a pre-emergence spray, gave a much higher yield than that of chlorpropham. The latter was applied as a pre-emergence spray in 50 gallons of water.

Chambers (1960) reported that the pre-emergence applications of CDAA, CIPC plus Monuron, Amiben, CDEC and Zytron gave good weed control in onions, except for Amiben which reduced onion yields significantly. Laliberte (1960) showed that Monuron at 1 lb per acre, applied as a pre-emergence spray, greatly reduced onion yields in two out of three years of experimentation.

Saghir and Worzella (1961) reported that the pre-emergence applications of used drained motor oil plus diesel oil, and Esteron Ten Ten gave no significant increases in onion yield as compared to the check. All other herbicides tested, namely Aerocynate, 2, 4-D amine, Simazine, DNOC, DNBP, CMU and CIPC, gave significantly lower yields than the check. Saghir (1966) has also shown that the pre-emergence application of Tok E-25 at 2 Kg per hectare and BV-201 at 2 and 4 Kg per hectare increased the onion yields about 10 percent over the check, but that this increase was not statistically significant. Pre-emergence applications of BV-201 and BV-207 at 6 Kg per hectare reduced onion yields significantly. Similar results were obtained in Brazil as a result of pre-emergence applications of Tok E-25 at the rates of 3.5 Kg, 4.5 Kg, and 5 Kg per hectare (Anonymous, 1964).

Post-emergence applications of trietazine at 4 lb per acre and Randox T at 4 lb per acre reduced onion yields by 35 and 25 percent, respectively, when onions were sprayed at the second leaf stage, and when the weeds were about one inch tall (Chambers, 1960). All other herbicides tested, namely Dicryl at 4 lb per acre, Karsel at 2 and 4 lb per acre, CIPC at 8 lb mixed with Diethanolamine salt of 2, 4-D at $\frac{1}{2}$ lb per acre and Atrazine at 2 lb per acre, practically eliminated the onion stands. Kzn (1960) and Bruinsma (1960) both observed that spraying weeds in onions with DNOC preparations often resulted in distinct increases in yield. 2,6-DBN, applied 23 days after sowing at 4 and 6 lb per acre as a post-emergence treatment, caused slight injury to onions (Hagood, 1960a; and Hagood, 1960b).

It was reported by Saghir and Worzella (1961) that the post-emergence applications of Aerocynanate, 2, 4-D amine, used drained motor oil plus diesel oil, Simazine, CMU, CIPC, and Esteron Ten Ten gave lower yields than the check, while DNBP and DNOC gave significantly higher onion yields over the check. Chubb (1962) showed that there was no significant difference between the onion yields of the hand weeded check plots of the "Autumn Spice" variety and that of plots treated with CDAA at 4 lb and 6 lb per acre, and CDAA plus CIPC each at 4 lb per acre. Yields from CDAA-T at 6 lb per acre and CDAA plus CIPC, each at the rate of 2 lb per acre, were not as good as those of CDAA plus CIPC each at 4 lb per acre. It has also been reported that yields of "Brigham Yellow Globe" onions showed no significant differences between weeded check plots and those treated with CDAA, CDAA plus CIPC and CDAA-T, all sprayed at 6 lb per acre. For both varieties tested, the yields from plots treated with Avadex at 2 lb per acre were significantly lower than those of weeded checks due to onion injury.

In 1967, Saghir reported that BV-207, BV-201,and Tok E-25 at 1 to 2 Kg per hectare gave promising results as post emergence sprays in onions. In addition, DNOC and DNBP at 1½ Kg per hectare, and Ioxynil at ½ Kg per hectare applied as post-emergence sprays were found to increase the yield of onions significantly as compared to the yields of check plots.

<u>Weeds</u>

Chambers (1960) reported, that the chemical control of the principle weeds found in his pre-emergence treated plots, namely those of purslane (<u>Portulaca oleracea</u>) and rough pigweed (<u>Amaranthus retroflexus</u>), was as follows: CDAA, 85 percent; CIPC plus

Monuron, 47 percent; and Simazine, 62 percent. Miller (1960) found that CDAA at 4 lb per acre, IPC at 8 lb per acre and DAC 893 at 8 lb per acre gave good weed control with no injury to onions when used as pre-emergence sprays. Saghir and Worzella (1961) showed that pre-emergence applications of DNOC and DNBP proved to be ineffective in controlling weeds. All other herbicides tested, namely Aerocynanate, 2,4-D amine, used drained motor oil plus diesel oil, Simazine, CMU, CIPC and Esteron Ten Ten gave significant weed control. Other herbicides which gave effective weed control when applied as a pre-emergence spray included CIPC at rates of 4 to 8 lb per acre, CDAA at 4 to 6 lb per acre and Endothal at 2.5 lb per acre (Klingman, 1961, pp. 272).

Nylund et al. (1962a) has shown that CIPC at 6 lb per acre controlled both broad-leaved weeds and grasses in onions, with no injury to the crop. The pre-emergence applications of 8 lb per acre of CIPC, CDAA-T, CDAA plus CIPC, and CDAA plus DMPA completely controlled Portulaca oleracea, Polygonum spp. and Amaranthus retroflexus (Nylund et al., 1962b). Pre-emergence applications of a mixture of 3 lb CIPC and 3 lb CDAA per acre gave the most economical weed control treatment in onions (Warren, 1962a), (Warren, 1962b), (Nylund et al., 1963a), (Nylund et al., 1963b), and (Nylund et al., 1964).

Nelson et al. (1960) found that the post-emergence applications of 6 lb per acre of CDAA (liquid and granular), 22 lb of CDAA-T (granular), 8 lb per acre of CIPC (granular), and 3 lb per acre of Amiben (granular) all gave from 85 to 100 percent weed control with no effect on onion yield. However, other herbicidal treatments tested gave satisfactory weed control but reduced the onion yields. These included the post-emergence applications of CDAA-T at the rate of 22 lb per acre (25 percent weed control); CIPC at 8 lb per acre (23 percent weed control); Diuron spray at 1 lb per acre (91 percent weed control); Diuron granules at 1 lb per acre (68 percent weed control); Monuron at 1 lb and 2 lb per acre gave 68 and 94 percent weed control, respectively.

Hagood (1960b) reported that post-emergence applications of 2, 6-DBN at the rates of 4 and 6 lb per acre killed 37 percent and 60 percent of the Avena fatua infestation, respectively, with slight injury to onions. Potassium cyanate was used as a post-emergence herbicide on onions to control Amaranthus retroflexus and Chenopodium album when these weeds were small (Klingman, 1961, pp. 265). Sukortseva et al. (1965) found that the post-emergence applications of 30 to 40 Kg per hectare of sodium trichloreacetate resulted in effective weed control.

Saghir (1966) reported that pre-emergence and post-emergence applications of Tok E-25 in onions controlled Saponaria vaccaria completely, but was partially effective against Amaranthus retroflexus and Portulaca oleracea. Moreover, BV-201 and BV-207 both controlled Saponaria vaccaria and Sinapis arvensis. Anderson et al. (1966) showed that when R-4461 was applied at the rate of 2 to 8 lb per acre, when the onions were at the flag stage, gave effective control of annual weeds with no injury to onions. The herbicide was more effective against grasses than against broad-leaved weeds. In Brazil, Leiderman and Santos (1967) found that the best control of dicotyledonous weeds was obtained when 0.5 to 1.0 Kg of Linuron and 4 to 5 Kg of Solan per hectare were applied. However, these compounds were toxic to onion seedlings. Applications of 3 to 4 Kg of Chloroxuron or Netrofen per hectare gave good weed control with no injury to onions.

Stand

It was shown by Hernandez et al. (1950) that the pre-emergence application of 2, 4-D at 4 lb per acre reduced the onion stands significantly. Saghir (1966) reported that pre-emergence applications of BV-207 at 2 Kg per hectare was selective in onions, but at 6 Kg per hectare, the herbicide resulted in great reductions in onion stands. Herron (1965) found that the post-emergence applications of Prometryne at 2 lb per acre caused a 25 percent reduction in stand. Similar observations were made by Dinkel (1965).

Leaf Length

The leaf is the main organ of the onion plant where photosynthetic activity takes place. It is consumed raw, as green onion, or dry after dehydration. The length, number, and the arrangement of onion leaves may have an effect on the stand and growth of the competitive weeds.

It was reported by Lachman (1963) that the height of onion plants was significantly reduced when Chloro IPC was applied as pre-emergence sprays at the rates of 6 lb per acre, while it was not adversely affected by an application of 2 lb per acre.

Bulb Size

Hernandez et al. (1950) found that the applications of 4 lb per acre of 2, 4-D as a pre-emergence spray increased the size of onion bulbs significantly, while Saghir and Worzella (1961) reported a serious reduction in the size of bulb by the pre-emergence applications of 2, 4-D amine.

Saghir and Worzella (1961) found also that the post emergence applications of Aerocyanate gave larger bulbs than those of the pre-emergence treatment. It was also shown that DNOC-treated onions were larger in their bulb diameters than those of the check.

Bulb Index

The bulb index, calculated as a ratio of the width of the onion neck/the diameter of the bulb, plays an important role in the grading system of onions. In addition, it gives an indication as to the storage quality of onions. Bulbs with smaller necks or bulb indices can be kept in storage for a longer period of time than those with a large bulb index (Jones and Mann, 1963, pp. 204-208).

Saghir (1967) reported that the pre-emergence and post-emergence applications of Tok E-25, BV-201, and BV-207 at the rates of 1 to 2 Kg per hectare, and the post-emergence applications of DNOC and DNBP at $1\frac{1}{2}$ Kg per hectare and Ioxynil at $\frac{1}{2}$ Kg per hectare had no significant effect on the bulb index. No other report is available on the effects of herbicides on the bulb index.

Moisture Content

Moisture percentage is a measure of the amount of dry matter and has a great effect on the storage and dehydration qualities of onions. Onions with high moisture contents do not keep long in storage and give low yields of dehydrated products. Onion bulbs vary in their dry matter content from 4 to 25 percent (Jones and Mann, pp.

204-208). Therefore, any changes which may occur in the moisture percentage of onions as a result of herbicidal sprays will be of significant importance.

The only report available on the effects of herbicides on moisture content of onions is that of Saghir (1967). He found that the pre-emergence and post-emergence applications of Tok E-25, BV-201 and BV-207 at 1 to 2 Kg per hectare, as well as the post-emergence applications of DNOC and DNBP at $1\frac{1}{2}$ Kg per hectare and Ioxynil at $\frac{1}{2}$ Kg per hectare had no significant effect on the moisture percentage of onions.

Total Soluble Solids

This constitutes the major portion of the total dry matter content of onions. Bennett (1941) found that the total soluble solids of the "Ebenzer" variety amounted to 65 percent of its total dry matter.

Saghir (1967) reported that the total soluble solids of onions were not affected by the applications of Tok E-25, BV-201, and BV-207 at 1 and 2 Kg per hectare as pre-emergence and post-emergence sprays. Also DNOC and DNBP at $1\frac{1}{2}$ kg per hectare applied as post-emergence sprays had no effects on the total soluble solids of onions.

Pungency

Onion pungency is not a well defined term, since it includes many characteristics such as the odor, the "burning" taste, and the lachrymatory factor. Saghir et al. (1964) reported that the volatiles responsible for the odor and flavor of onions are absent in the intact tissue and that they are enzymatically produced when the tissue is injured. The precursors for the production of these volatiles are known as alliins, which are derived from the amino acid cysteine. These derivatives react with the enzyme, allinase, to give allicins, pyruvic acid, and ammonia. The alliins are unstable compounds and produce different sulfides as breakdown products. These sulfides are considered responsible for the odor and flavor of onions. (Bernhard et al., 1964; Saghir et al., 1965; Yamaguchi et al., 1965; Saghir et al., 1966a; and Saghir et al., 1966b).

Saghir and Mann (1965) have also reported that crushing the onions will result in the formation of the lachrymatory factor which is produced enzymatically as follows: a non-volatile stable precursor, characterized as (+)-S-(prop-l-enyl)-L-cystiine sulphoxide, splits to form ammonia, pyruvic acid, and propenyl sulphenic acid. The latter compound was identified as the lachrymatory factor (Virtanen et al., 1961).

Schwimmer and Weston (1961) described a colorimetric method for the determination of onion pungency by measuring the amounts of pyruvic acid produced enzymatically as a result of onion comminution. Over 95 percent of the pyruvic acid is produced within 6 minutes after the start of comminution. The total amount produced is generally related to the degree of onion pungency. Weak onions produced 2 to 4 μ moles, those of intermediate strength 8 to 10 μ moles, and strong onions produced 15 to 20 μ moles of pyruvic acid per gram of fresh onion.

Pungency is considered as one of the most important qualities affecting the flavor of onions. Highly pungent onions have better flavor, greater amounts of dry matter, and can be kept in storage for a longer period of time as compared with low pungent onions (Jones and Mann, 1963, pp. 67-69). Onions which are highly pungent are the ones used mostly for dehydration purposes in Lebanon[1].

The only report available on the effect of herbicides on onion pungency is that of Saghir[2]. He showed that the pre-emergence applications of BV-207 at 1, 2, and 3 Kg per hectare and DNOC at 1 Kg per hectare reduced the pungency significantly, while Tok E-25 and BV-201 each at 1, 2, and 3 Kg per hectare and Ioxynil at ½, 1, and 1½ Kg per hectare and DNOC at 1½ and 2 Kg per hectare did not have any significant effect. In the case of post-emergence treatments, Tok E-25 at 1 and 2 Kg per hectare and DNOC at 1½ Kg per hectare reduced onion pungency while BV-201, BV-207, and Ioxynil had no effects.

Effect of Herbicides Studied on Yield and Quality of Onions

C 6313

C 6313 is a urea compound which is used selectively as a soil or foliage applied herbicide. It has a water solubility of 50 ppm and is formulated as 50 percent (active ingredient) wettable powder. It was found to be a powerful inhibitor of photosynthesis since it interfered with the Hill reaction (Anonymous, 1966a).

C 6313 has a powerful scorching effect on several important species of broad-leaved weeds when applied both as a pre-emergence

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1. Personal communication from Mr. Saleh A. Katbeh. Food Products Est. Beirut, Lebanon.

2. Saghir, A.R. 1968. Unpublished data. Faculty of Agricultural Sciences. American University of Beirut. Beirut, Lebanon.

or post-emergence spray. Good weed control was obtained at 1.0 Kg (a.i.) per hectare on sandy soils, and at 2.5 Kg (a.i.) per hectare on clay soils or on soils high in humus content (Anonymous, 1966a). No literature is available on the use of this herbicide on onions.

Tenoran

This herbicide which is also a urea compound is formulated as 50 percent wettable powder. It is effective as a soil applied herbicide since it is taken up mainly by the roots and to a limited extent by the leaves. The rate of application varies between 6 and 9 Kg per hectare depending on soil texture (Anonymous, 1966b). No data are available on the effect of this herbicide on onions.

Ramrod

It is an Anilide compound which was coded as C.P. 31393. It is 65 percent (a.i.) wettable powder used as a pre-emergence spray. Ramrod controls mainly annual grasses with a limited effect on broad-leaved weeds. Good weed control was obtained at the rates of 3.5 to 5.0 Kg (a.i.) per hectare when the broad leaved weeds were between the cotyledoneous and the 2.5 leaf stage, and when the grassy weeds were at the one leaf stage (Anonymous, 1966c).

Field trials in Europe and North America had shown that onions were tolerant to Ramrod up to 7 Kg (a.i.) per hectare with no residual effect in the soils (Anonymous, 1966c). No further data are available on the effect of Ramrod on onions.

CP 50144

This is a coded pre-emergence herbicide and its chemical formula has not been released yet. It is experimentally used for the control of grassy and broad-leaved weeds in onions and other crops. Application rates have been suggested to range from 560 g to 4,480 g (a.i.) per hectare (1.2 to 9.3 liters of the formulation per hectare). Post-emergence applications, were found to be slightly less effective than pre-emergence treatments. These applications were done prior to the $2\frac{1}{2}$ leaf stage of onions (Anonymous, 1966d). No further literature is available on the use of this herbicide in onions.

Sindone

This chemical, formerly known as Amchem D-263, is a new pre-emergence herbicide which is quite persistant in the soil and has extremely low water solubility. It is active against grasses, but tolerated well by most broad-leaved weeds and crops. The only information available on the effects of this herbicide on onions is that good results were obtained in Michigan, U.S.A. using up to 20 lb per acre of Sindone on muck soils. Similar results were obtained on mineral soils (Anonymous, 1966e).

Stam F-34

This is an emulsifiable liquid concentrate, soluble in water at 225 ppm at room temperature (Woodford and Evans, 1963 pp. 300-301). It enters through the leaves and controls many monocotyledonous and dicotyledonous weed seedlings, particularly grasses at doses of 2 to 4 lb per acre, when applied as a foliar spray. It has shown little activity when sprayed on weeds prior to emergence (Woodford and Evans, 1963, pp. 272).

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Saghir and Worzella (1961) reported that both pre-emergence and post-emergence applications of Stam F-34 gave higher yields of onion than the check. The yields from post-emergence sprayed plots were relatively higher than those of the pre-emergence treatments. However, these differences were not statistically significant. In pre-emergence applications, at rates of 0.25, 0.75, and 1.50 lb per acre, 21.4 to 28.5 percent of the onions were injured. At the higher post-emergence rate of 1.5 lb per acre, the herbicide gave good weed control. Mustards (Sinapis arvensis) were severely injured, and in most cases were completely killed, but no injury was observed on lambsquarter (Chenopodium album) and field bindweed (Convolvulus arvensis).

Prometryne

This is a formulation of the triazine herbicides and has a water solubility of 48 ppm. It is absorbed both by the roots and leaves. Prometryne does not inhibit the seed germination of weeds, but affects young weed seedlings shortly after their emergence. This toxicity is due to the blocking of the process of photosynthesis through inhibition of the Hill reaction (Anonymous, 1962).

Gysin et al. (1960) compared the inhibition effect of Prometryne with that of Simazine and found that Prometryne inhibited the Hill reaction 6.1 to 9.1 times as much as Simazine.

Simazine, which belongs to the same group as that of Prometryne, was tested in onions by Saghir and Worzella (1961). They reported that it was ineffective as a selective herbicide in onions when applied both as pre-emergence and post-emergence sprays. The onions were almost completely killed at the rates of 0.5, 1.0, and 1.5 lb per acre tested. The weed control ranged from 38.9 to 88.5 percent and from 53.6 to 85.3 percent for pre-emergence and post-emergence treatments, respectively. Mustards (Sinapis arvensis) and lambsquarter (Chenopodium album) were severely injured, while field bindweed (Convolvulus arvensis) was somewhat resistant.

Post-emergence applications of Prometryne on onions were effective, but tended to injure the crop if applied before the one leaf stage, or if the application was followed by heavy rains (Anonymous, 1966f).

III. MATERIALS AND METHODS

The experiment was conducted at the Agricultural Research and Education Center (AREC) of the American University of Beirut during 1967. The AREC is located in the Beqa'a Plain, about 80 kilometers east of Beirut. The soil is calcareous clay, low in organic matter, with a PH of approximately 8.0. The climate of the experimental area is generally hot and dry in summer and cold in winter, with unequal distribution of rainfall. During the experiment, the minimum temperature recorded in April was 4.0°C. The maximum temperature occured in August and was 31.5°C. The distribution of rainfall during the growing season was as follows: 20.5 mm in April, 34.5 mm in May and no rain in June, July, August, and September.

Field Methods

The experimental plots were under vetch pasture before being planted to onions. Nitrogen and phosphate fertilizers were applied before planting at the rates of 12 Kg of N and 20 Kg of P_2O_5 per dunum[1]. Healthy sets of onions of the "Souri" variety were spaced 15 x 15 cm and planted in basins on April 12, 1967. Each basin was 5 meters long and 1 meter wide. These basins were arranged in a randomized complete block design with three replications.

Pre-emergence application of herbicides was made six days after

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1. One dunum is equal to 1000 square meters.

planting, and the post-emergence application six weeks after planting. The herbicides were applied at a constant pressure, using a Knapsack sprayer equipped with a one-nozzle boom. Spraying operations were carried out early in the morning when there was little air movement.

Seven herbicides were tested, each at three different rates. The common or commercial names, active ingredient of the formulated products, and rates of the herbicides used are given in Table 1. Unweeded check plots, sprayed with water, were included in each experiment.

Table 1. The common names, percent active ingredient, and rates of herbicides tested at the AREC during 1967.

Common or commercial name[1]	Percent active ingredient (a.i.)	Rates tested in Kg (a.i.) per hectare[2]
C 6313	50	1.0, 2.0, 3.0
Tenoran	50	2.0, 4.0, 6.0
Ramrod CP 31393	65	4.0, 6.0, 8.0
CP 501144	48	1.0, 2.0, 4.0
Sindone	24	0.5 1.0, 1.5
Stam F-34	50	0.5, 1.0, 1.5
Prometryne	50	0.5, 1.0, 1.5

1. Chemical names of the herbicides are listed in Appendix A.

2. Dissolved in 1600 liters of water per hectare.

Six sprinkler irrigations, each for $1\frac{1}{2}$ hours (37 mm/hr) were given during the interval between pre-emergence and post-emergence treatments and 44.4 mm of rain fell, totalling 377.4 mm. After the post-emergence application, two further sprinkler irrigations were given amounting to 110 mm, followed by weekly basin irrigations until three weeks before the time of harvesting (September 7, 1967). There was no rainfall between the post-emergence application and the time of harvesting.

The weed species which were commonly found in the experimental plots were Circium arvensis, Saponaria vaccaria, Sinapis arvensis which are annuals. In addition, some perennials were found such as Anchuza italica, Convolvulus arvensis and Lepidium chalepense.

Data Recording

Weed and onion counts were made, three months after planting, in two square meters per basin. Phytotoxicity notes on weeds and onions were also recorded. In addition, other agronomic characteristics were evaluated. The leaf length was measured in centimeters from the base of the longest onion leaf to its tip. Three randomly chosen leaves were measured per basin. The fresh weight of onions was obtained after digging out the bulbs in each basin and trimming their leaves and roots. Onion yields were calculated on the basis of kilograms per dunum.

The diameter of onion bulbs and the thickness of their necks were measured in centimeters by means of a Vernier caliper. The bulb index was calculated by dividing the thickness of the neck by the bulb diameter. Six onion bulbs from each basin were used for these determinations. The average fresh weight per bulb was found by dividing the total fresh weight of onions over the numbers of onions harvested from each basin.

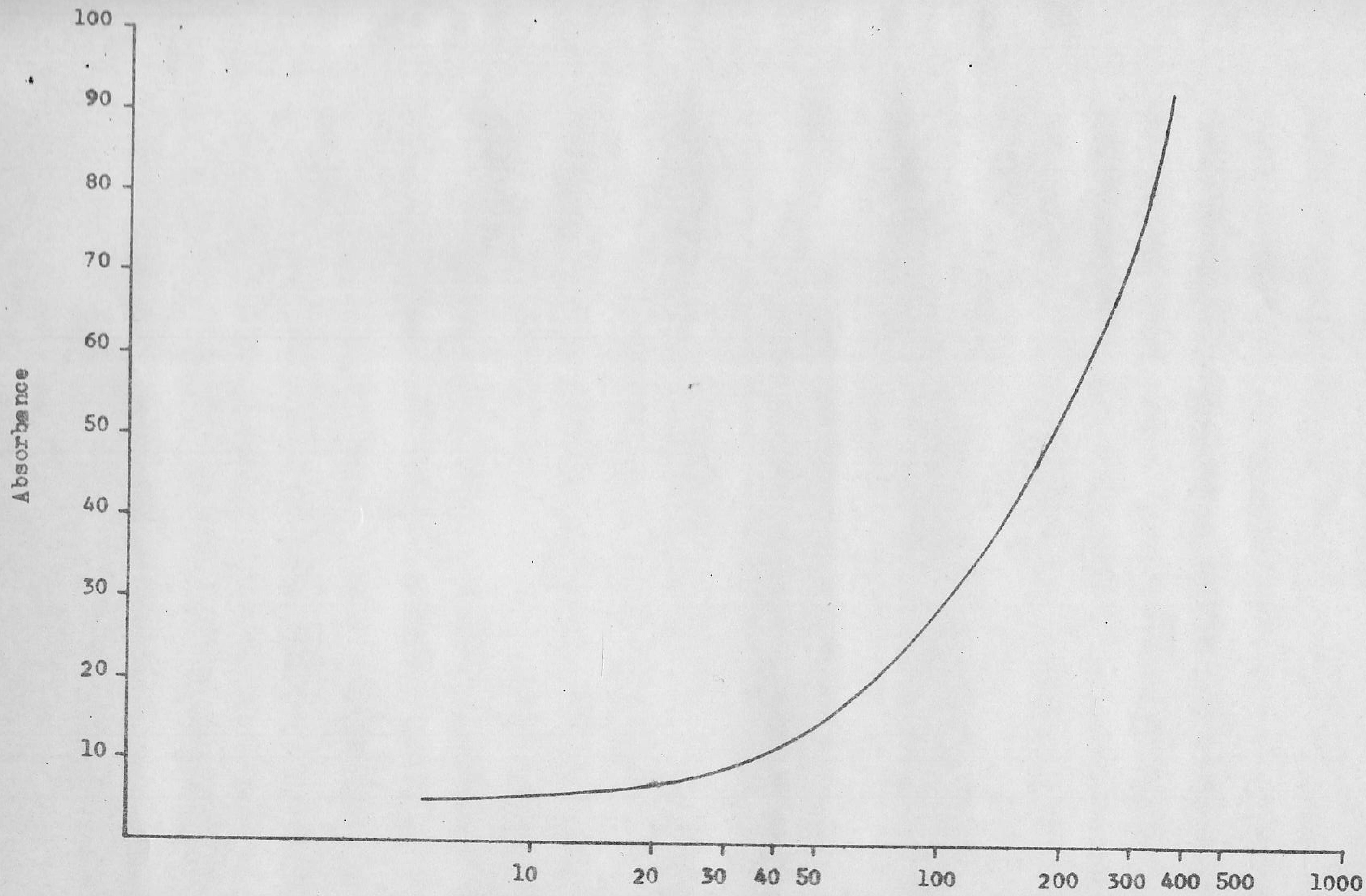
Laboratory Methods

The moisture percentage was determined by placing 20 grams of chopped onions, in triplicate, in a Freas P.S. Model 144 oven at 60°C for 48 hours. Total soluble solids were measured by placing three drops of onion juice in a Bausch & Lomb Abbe refractometer set at 20°C. Duplicates were determined on each treatment.

For pungency determinations, the method of Schwimmer and Weston (1961) was used with modifications made by Saghir *et al*. (1964). The method essentially measures the enzymatically liberated pyruvic acid in the different herbicidal treatments and in the controls. This was determined colorimetrically by measuring the total 2, 4-dinitrophenyl hydrazine - reacting carbonyls. A detailed flow sheet of the chemical analysis is shown in Appendix B. In addition, Figure 1 shows the calibration curve, using sodium pyruvate as a standard. Micromoles of pyruvate in the final chromogenic solution were plotted *vs* absorbence.

Statistical Analysis

The statistical analysis was done according to the methods described by LeClerg *et al*. (1962, pp. 137-144). The least significant differences were calculated at the 5 percent level for making comparisons between different treatments and the check.



Sodium pyruvate, μ moles

Figure 1. Calibration curve using sodium pyruvate as standard.

IV. RESULTS AND DISCUSSION

The effects of seven herbicides on weed count, onion stand, leaf length, bulb size, bulb index, yield, moisture percentage, total soluble solids, and pungency of onions are presented in Tables 2 to 7. Analysis of variance Tables 8 to 15 are given in Appendix C.

Phytotoxicity and Weed Count

Phytotoxicity notes and weed counts were taken three months after planting. In the pre-emergence application, the herbicides applied gave excellent weed control at all rates tested except in the case of Ramrod, at 8 Kg (a.i.) per hectare, where reductions in weed count were not statistically significant (Table 2). This may be explained by the fact that Ramrod kills mainly the grassy weeds which were not present in large amounts in the plots.

Percent weed control in the pre-emergence applications ranged from 51.5 to 63.4 percent in the case of C 6313 and 37.0 to 58.6 percent in the case of Tenoran. Ramrod range of weed control was low with 23.8 to 36.1 percent; whereas, CP 50144 controlled 37.0 to 45.8 percent of the weeds. Sindone gave 32.6 to 58.1 percent weed control and Stam F-34 and Prometryne resulted in 33.9 to 48.0 and 35.7 to 41.4 percent weed control, respectively.

It was observed that the post-emergence treatment of C 6313 at 2 Kg (a.i.) per hectare was effective in controlling _Sinapis arvensis_ and _Saponaria vaccaria_; Stam F-34 at 1 Kg (a.i.) per hectare

Table 2. The effect of pre-emergence and post-emergence applications of herbicides on the number of weeds and onions in 1967.

Herbicide	Rate Kg/ha (a.i.)	Weeds[1] per sq. meter		Onions[1] per sq. meter	
		Pre-emergence	Post-emergence	Pre-emergence	Post-emergence
C 6313	1.0	11.0	9.7	44.6	40.3
	2.0	8.3	4.0	38.1	35.4
	3.0	10.5	4.8	34.7	34.0
Tenoran	2.0	14.2	6.7	40.0	37.8
	4.0	12.4	12.0	36.8	43.1
	6.0	9.3	11.8	34.3	34.0
Ramrod	4.0	14.3	10.6	34.4	34.3
	6.0	11.4	12.7	30.1	37.0
	8.0	17.1	13.0	32.7	40.4
CP 50144	1.0	14.2	7.7	32.3	32.2
	2.0	9.7	7.2	38.2	34.6
	4.0	12.0	12.3	37.4	37.0
Sindone	0.5	15.3	13.1	35.7	33.3
	1.0	9.8	16.0	38.8	33.2
	1.5	9.7	16.7	37.3	36.8
Stam F-34	0.5	11.7	11.0	32.7	38.7
	1.0	15.1	12.4	45.0	32.0
	1.5	14.7	14.8	35.7	35.0
Prometryne	0.5	12.0	9.3	35.0	37.2
	1.0	14.8	3.0	28.8	35.1
	1.5	13.4	9.1	30.7	33.2
Check	0.0	22.7	11.2	34.7	37.0
LSD 5%	—	7.4	8.4	14.0	9.7

1. Average of six readings.

controlled Lepidium chalepense and Sinapis arvensis; and Prometryne at 1.5 Kg (a.i.) per hectare gave good control of Convolvulus arvensis and Lepidium chalepense. It was also noted that CP 50144 had no effect on Anchuza italica, Circium arvensis, Saponaria vaccaria and Sinapis arvensis. Chlorosis of Sinapis arvensis was also observed in the post-emergence applications of C 6313 at 2 and 3 Kg (a.i.) per hectare; Tenoran at 2 and 4 Kg (a.i.) per hectare; Stam F-34 at 0.5, 1 and 1.5 Kg (a.i.) per hectare; and Prometryne at 0.5 and 1 Kg (a.i.) per hectare.

Weed count was not significantly affected by the post-emergence application. This was expected since the herbicides used act mostly through the soil. Weed control ranged between zero and 18.2 percent, except for C 6313 at 2 and 3 Kg (a.i.) per hectare and CP 50144 at 1 and 2 Kg (a.i.) per hectare, where weed counts were reduced by 63.6, 57.3, 30.0, and 33.6 percent, respectively.

Onion Stand

Onion stand is considered as one of the main factors in determining the yield. The larger the number of plants per unit area, the higher the yield and the greater the selectivity of the herbicide used. Figure 2 shows that the pre-emergence application of Prometryne at 1 Kg (a.i.) per hectare caused severe injury to onion leaves. Similar leaf injury was observed as a result of the post-emergence application of Prometryne at 1 and 1.5 Kg (a.i.) per hectare. This injury may be due to the blocking of the Hill reaction which results in stopping photosynthesis and the ultimate death of the plants.

Untreated

Prometryne treated

Figure 2. The effect of pre-emergence application of Prometryne at 1 Kg (a.i.) per hectare on weeds and onions.

Onion counts were made three months after planting. The data presented in Table 2 show that the herbicides had no significant effect on the onion stand in both pre-emergence and post-emergence applications. Onion plants per square meter ranged from 29.0 to 45.0 plants in the basins which received the pre-emergence application, and from 32.0 to 43.0 plants in those which received the post-emergence application.

Prometryne at 1 and 1.5 Kg (a.i.) per hectare reduced the onion stand by 17.0 and 11.6 percent, respectively, in the case of the pre-emergence treatment and 5.4 and 18.9 percent in the post-emergence treatment. Saghir and Worzella (1961) reported that Simazine, which belongs to the same Triazine group as that of Prometryne, resulted in the complete kill of the onion stand. They have also reported 21.4 to 28.5 percent onion injury in the case of the pre-emergence application of Stam F-34; whereas no injury has occured in onions treated with Stam F-34 in this study.

<u>Leaf Length</u>

The leaf is the seat of the process of photosynthesis. Any injury which results from herbicidal treatments will cause a reduction in the leaf area and will have a severe effect on the yield and quality of onion bulbs. Figure 2 shows that Prometryne at 1 Kg (a.i.) per hectare applied as a pre-emergence spray caused severe injury to the leaves which resulted in low yields.

Table 3 indicates the effects of herbicides on leaf length. The average length in both pre-emergence and post-emergence applications ranged from 48.1 to 54.9 cm. No significant effect on leaf length was

Table 3. The effect of pre-emergence and post-emergence applications of herbicides on onion leaf length[1], in cm, 1967.

Herbicide	Rate Kg/ha (a.i.)	Pre-emergence	Post-emergence
C 6313	1.0	50.2	50.0
	2.0	54.0	54.9
	3.0	48.2	51.5
Tenoran	2.0	49.0	49.3
	4.0	54.9	54.8
	6.0	51.8	51.5
Ramrod	4.0	50.7	52.3
	6.0	50.3	52.9
	8.0	50.4	52.2
CP 50144	1.0	49.8	52.7
	2.0	50.0	50.8
	4.0	48.1	48.1
Sindone	0.5	50.8	50.2
	1.0	50.0	52.3
	1.5	53.8	54.0
Stam F-34	0.5	52.3	50.7
	1.0	49.2	50.3
	1.5	51.3	50.3
Prometryne	0.5	50.9	49.4
	1.0	48.9	52.3
	1.5	52.3	51.9
Check	0.0	50.7	50.1
LSD 5%	—	4.7	6.1

1. Average of nine readings.

observed as a result of pre-emergence and post-emergence applications.

Bulb Size

The bulb size seems to be more affected by cultural practices, climatic and other environmental conditions than by herbicidal treatments. Data in Table 4 indicate that the bulb diameter, in the pre-emergence and post-emergence sprayed plots, ranged from 5.83 to 7.00 cm and 5.97 to 7.23 cm, respectively. The average bulb weight ranged from 124 to 168 g and from 112 to 148 g in the pre-emergence and post-emergence treatments, respectively.

The pre-emergence applications of Tenoran at 6 Kg (a.i.) per hectare and Sindone at 1.5 Kg (a.i.) per hectare resulted in an increased bulb weight, which was 20.9 percent and 20.1 percent, respectively, over that of the check; however, these increases were not statistically significant. All other herbicides tested had also no significant effect on bulb size.

Bulb Index

Table 4 shows that the onion bulb index was not significantly affected by the applications of herbicides. The indices ranged from 0.19 to 0.25 and 0.23 to 0.27 in the pre-emergence and post-emergence applications, respectively. This is in agreement with the results of Saghir (1967) who reported no significant effect of herbicides used on the bulb index of onions.

Yield

The effects of herbicides on the yield of onions are summarized in Table 5. The pre-emergence applications of Tenoran at 6 Kg (a.i.)

Table 4. The effect of pre-emergence and post-emergence applications of herbicides on bulb diameter, bulb index, and bulb weight in 1967.

Herbicide	Rate Kg/ha (a.i.)	Bulb diameter[1] (cm)		Neck/diameter[1] (bulb index)		Fresh weight/bulb (in g)	
		Pre-emergence	Post-emergence	Pre-emergence	Post-emergence	Pre-emergence	Post-emergence
C 6313	1.0	5.83	6.60	0.22	0.25	128	148
	2.0	6.73	6.37	0.21	0.24	139	142
	3.0	6.77	6.93	0.22	0.24	135	136
Tenoran	2.0	7.00	6.90	0.20	0.25	150	112
	4.0	6.80	6.56	0.22	0.25	145	132
	6.0	6.43	0.23	0.27	0.27	168	126
Ramrod	4.0	6.40	7.23	0.23	0.25	133	132
	6.0	6.10	7.13	0.22	0.23	130	148
	8.0	6.10	6.57	0.24	0.24	145	147
CP 50144	1.0	6.27	6.60	0.25	0.23	142	122
	2.0	6.87	6.87	0.24	0.23	127	127
	4.0	6.93	6.73	0.21	0.24	132	134
Sindone	0.5	6.77	6.80	0.22	0.24	127	127
	1.0	6.03	6.70	0.24	0.25	127	124
	1.5	6.93	6.70	0.21	0.25	167	132
Stam F-34	0.5	6.17	5.97	0.24	0.25	144	135
	1.0	6.57	6.70	0.19	0.25	124	145
	1.5	6.86	6.87	0.23	0.24	141	126

(Table 4 Continued)

Prometryne	0.5	6.43	6.70	0.24	0.25	156	141
	1.0	6.43	6.70	0.23	0.25	133	133
	1.5	6.90	6.63	0.22	0.24	153	126
Check	0.0	6.60	6.63	0.22	0.24	139	130
LSD 5%	—	0.97	0.92	0.16	0.06	28	33

1. Average of 18 readings.

Table 5. The effect of pre-emergence and post-emergence applications of herbicides on the yields, in kilograms, and moisture percentage of onions in 1967.

Herbicide	Rate Kg/ha (a.i.)	Yield/dunum[1]		Moisture percentage[2]	
		Pre-emergence	Post-emergence	Pre-emergence	Post-emergence
C 6313	1.0	5033	5442	81.8	77.9
	2.0	4857	4918	79.2	78.1
	3.0	3864*	4036	80.8	77.9
Tenoran	2.0	5484	4933	81.0	78.6
	4.0	4881	4700	80.8	78.7
	6.0	5484*	4106	80.8	78.8
Ramrod	4.0	5130	5009	80.7	79.7
	6.0	4403*	4339	78.6	79.3
	8.0	4576	5639	80.0	79.4
CP 50144	1.0	4677	4721	80.9	80.4
	2.0	4933	4500	78.5	77.4
	4.0	4933	4333	81.7	79.4
Sindone	0.5	4454*	4539	80.4	77.9
	1.0	4857	4205	81.5	77.8
	1.5	5290*	3975	79.9	79.6
Stam F-34	0.5	4675	4211	80.8	78.4
	1.0	4806	5327	80.4	80.2
	1.5	4791	4136	79.7	79.1
Prometryne	0.5	4571	5236	79.5	77.2
	1.0	3749*	4857	79.6	79.2
	1.5	3718*	3612*	80.0	80.1
Check	0.0	4865	4812	79.7	79.1
LSD		318	1130	2.2	2.9

* Different from the check at 5 percent level of significance.

1. Average of three readings.

2. Average of nine readings.

per hectare and Sindone at 1.5 Kg (a.i.) per hectare gave a significant increase in the yield of onion over the unweeded check. This increase amounted to 12.9 percent and 8.7 percent over the check for Tenoran and Sindone, respectively. In addition, C 6313 at 1 Kg (a.i.) per hectare and Ramrod at 4 Kg (a.i.) per hectare increased the yields by 3.5 percent and 5.4 percent, respectively. However, these increases were not statistically significant.

Serious reductions in yield were observed as a result of pre-emergence applications of C 6313 at 3 Kg (a.i.) per hectare (20.6 percent), Ramrod at 6 Kg (a.i.) per hectare (9.5 percent), Sindone at 0.5 Kg (a.i.) per hectare (8.4 percent), and Prometryne at 1 and 1.5 Kg (a.i.) per hectare (22.9 and 23.6 percent, respectively). The other herbicides tested, namely CP 50144 and Stam F-34, had no significant effect on onion yields.

With the exception of Prometryne at 1.5 Kg (a.i.) per hectare, the post-emergence applications of herbicides tested had no significant effects on onion yield. Prometryne resulted in a significant reduction in the yield amounting to 24.9 percent less than the check. This result will label Promtryne as a nonselective herbicide in onions, which is in agreement with the conclusions of Saghir and Worzella (1961) who reported complete non-selectivity of Simazine, a herbicide related to Prometryne.

<u>Moisture Percentage</u>

The moisture percentage, which indicates the amount of dry matter in onions, is considered as an important factor which determines the best onions to be used for dehydration. Therefore, it is of prime importance that the onions must have a high amount of dry matter in order to give a good dehydrated product. Onion bulbs vary in their moisture percentages from 75 to 96 percent (Jones and Mann, 1963, pp. 204-208).

The moisture content of the onions studied (Table 5) ranged from 78.5 to 81.5 percent in the case of pre-emergence treatments, and 77.2 to 80.4 percent in the case of post-emergence applications. The results indicate that onions obtained from the pre-emergence treated plots had a slightly greater percentage of moisture than those obtained from the post-emergence treated plots. However, the differences observed were not statistically significant which agreed with the results obtained by Saghir (1967).

Total Soluble Solids

Table 6 indicates that the herbicides tested had no significant effect on the percent total soluble solids of onions. The data ranged from 14.1 to 18.8 percent total soluble solids in the pre-emergence treatments and from 13.9 to 17.7 percent in the post-emergence applications.

CP 50144 at 2 Kg (a.i.) per hectare gave the highest amount of total soluble solids in the pre-emergence applied plots (Table 6), whereas Ramrod at 6 Kg (a.i.) per hectare gave the lowest amount. In the post-emergence applications, C 6313 at 1 and 2 Kg (a.i.) per hectare, gave an increase of 3.1 and 2.9 percent total soluble solids over the check, respectively. CP 50144 at 1 and 2 Kg (a.i.) per hectare also gave an increase of 3.1 and 2.4 percent total soluble solids over the check. However, these differences were not

Table 6. The effect of pre-emergence and post-emergence applications of herbicides on percent total soluble solids[1] of onions in 1967.

Herbicide	Rate Kg/ha (a.i.)	Pre-emergence	Post-emergence
C 6313	1.0	15.7	17.7
	2.0	14.8	17.5
	3.0	15.3	16.7
Tenoran	2.0	15.1	13.9
	4.0	15.5	15.1
	6.0	15.2	16.2
Ramrod	4.0	15.3	15.6
	6.0	14.1	16.5
	8.0	14.3	16.2
CP 50144	1.0	14.3	17.7
	2.0	18.8	17.0
	4.0	15.7	15.8
Sindone	0.5	16.3	16.3
	1.0	15.6	14.9
	1.5	16.0	16.6
Stam F-34	0.5	16.5	16.3
	1.0	16.4	16.7
	1.5	14.4	16.4
Prometryne	0.5	16.3	16.9
	1.0	14.2	16.1
	1.5	15.5	15.6
Check	0.0	15.9	14.6
LSD 5%	—	3.2	3.3

1. Average of six readings.

statistically significant, and are in agreement with the results reported by Saghir (1967).

Pungency

The range of the pyruvic acid content of the onions under study was from 2.90 to 3.93 micromoles per gram of onion fresh weight, in the case of pre-emergence treatments, and 3.04 to 4.07 micromoles for post-emergence applications (Table 7). This indicates that these onions are low in pungency and may not be used for dehydration purposes.

Table 7 shows that there was no significant effect of the herbicides tested on the amount of pyruvic acid produced. These results do not agree completely with the data obtained by Saghir[1], who showed some effect of herbicides on onion pungency. This variation may be due to the different herbicides used in Saghir's experiment.

1. Saghir, A.R. 1968. Unpublished data. Faculty of Agricultural Sciences. American University of Beirut. Beirut, Lebanon.

Table 7. The effect of pre-emergence and post-emergence applications of herbicides on the pyruvic acid content, in micromoles per gram of fresh onion[1] in 1967.

Herbicide	Rate Kg/ha (a.i.)	Pre-emergence	Post-emergence
C 6313	1.0	2.98	3.61
	2.0	3.87	3.04
	3.0	3.65	3.28
Tenoran	2.0	3.26	3.67
	4.0	3.11	3.67
	6.0	3.93	3.67
Ramrod	4.0	3.57	4.07
	6.0	3.34	3.64
	8.0	2.98	3.95
CP 50144	1.0	3.81	3.62
	2.0	3.89	3.75
	4.0	3.46	3.85
Sindone	0.5	3.32	4.00
	1.0	3.80	3.77
	1.5	3.14	3.64
Stam F-34	0.5	2.90	3.23
	1.0	2.96	3.54
	1.5	3.43	3.46
Prometryne	0.5	3.63	3.47
	1.0	3.08	3.68
	1.5	3.21	3.91
Check	0.0	3.45	3.49
LSD 5%	—	0.95	1.07

1. Average of six readings.

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The experiments were conducted at the Agricultural Research and Education Center of the American University of Beirut during 1967. The objective of this study was to evaluate the effects of seven different herbicides, applied as pre-emergence and post-emergence sprays, on the yield and quality of onions and to observe their effects on the weed population. The experiments were arranged in a randomized complete block design with three replications.

The herbicides tested were C 6313 at 1, 2, and 3 Kg (a.i.) per hectare; Tenoran at 2, 4, and 6 Kg (a.i.) per hectare; Ramrod at 4, 6, and 8 Kg (a.i.) per hectare; CP 50144 at 1, 2, and 4 Kg (a.i.) per hectare; and Sindone, Stam F-34 and Prometryne each at 0.5, 1, and 1.5 Kg (a.i.) per hectare. Unweeded check plots were included in each replication. Phytotoxicity notes on onions and weeds were recorded. Data on onion stand, leaf length, bulb size, bulb index, yield, moisture percentage, total soluble solids, and pungency were collected.

In general, all the herbicides tested gave good weed control as a result of the pre-emergence application, while only chlorosis was observed on weeds in the case of the post-emergence treatment. Injury to onions occured only in the Prometryne treated plots both as pre-emergence and post-emergence applications.

Pre-emergence applications of Tenoran at 6 Kg (a.i.) per hectare and Sindone at 1.5 Kg (a.i.) per hectare caused a significant increase in the yields of onions as compared to the unweeded check. Other herbicides tested, namely C 6313 at 3 Kg (a.i.) per hectare, Ramrod at 6 Kg (a.i.) per hectare, Sindone at 0.5 Kg (a.i.) per hectare and Prometryne at both 1 and 1.5 Kg (a.i.) per hectare resulted in significant reductions in onion yields. All other rates of herbicides used had no significant effect on the yield.

In the case of post-emergence applications, no significant effect was observed on the yield of onions, except for Prometryne at 1.5 Kg (a.i.) per hectare which caused a significant reduction in the yield.

None of the treatments, in both pre-emergence and post-emergence applications, had any significant effect on the stand, leaf length, bulb size, bulb index, moisture percentage, total soluble solids, nor pungency of onions.

On the basis of the present study, it may be concluded that the pre-emergence applications of Tenoran at 6 Kg (a.i.) per hectare and Sindone at 1.5 Kg (a.i.) per hectare were the most effective treatments for the control of weeds in onions which resulted in yield increases with no adverse effects on the quality of onions.

It may be recommended that further studies be made on the use of higher rates of Tenoran and Sindone in onions since yields were found to increase with an increase in the rate of application of these two herbicides; whereas lower rates of C 6313 and Ramrod may be tested to study their effects on the yield. Since quality characteristics of onion were not affected by the application of herbicides used in the present study, further work may be recommended to evaluate other new herbicides suggested to be used on onions, and to determine their effects on moisture percentage, total soluble solids, pungency and probably on the odor or volatile constituents of onions.

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A P P E N D I X

Appendix A

Chemical Names of the Herbicides Cited in the Review of Literature

Aerocyanate	Potassium cyanate.
Amiben	3-amino-2, 5-dichlorobenzoic acid.
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-1, 3, 5-triazine.
Avadex	2, 3-dichloroallyl diisopropyl thio carbamate.
BV - 201	1-(3, 4-dichlorophenyl)-3-methyl-2-pyrrolidinone.
BV - 207	1-(3-chloro-4-methylphenyl)-3-methyl-2-pyrrolidinone.
$Ca(CN)_2$	Calcium cyanamide.
CDAA	NN-diallylchloroacetomide.
CDAA-T	See Randox - T.
CDEC	2-chloroallyl-NN-diethyldithiocarbamate.
Chloro IPC	See Chlorpropham.
Chlorproprophan	Isopropyl-N-(3-chlorophenyl) carbamate.
CIPC	See Chlroprophan.
CMU	See Monuron.
CP 50144	Not released yet.
C 6313	N-(4-bromo-3-chlorophenyl)-N'-methoxy N' methyl urea.

Appendix A

Chemical Names of the Herbicides Cited in the Review of Literature

Aerocyanate	Potassium cyanate.
Amiben	3-amino-2, 5-dichlorobenzoic acid.
Atrazine	2-chloro-4-ethylamino-6-isopropylamino -1, 3, 5-triazine.
Avadex	2, 3-dichloroallyl diisopropyl thio carbamate.
BV - 201	1-(3, 4-dichlorophenyl)-3-methyl-2-pyrrolidinone.
BV - 207	1-(3-chloro-4-methylphenyl)-3-methyl-2-pyrrolidinone.
$Ca(CN)_2$	Calcium cyanamide.
CDAA	NN-diallylchloroacetomide.
CDAA-T	See Randox - T.
CDEC	2-chloroallyl-NN-diethyldithiocarbamate.
Chloro IPC	See Chlorpropham.
Chlorproprophan	Isopropyl-N-(3-chlorophenyl) carbamate.
CIPC	See Chlropropham.
CMU	See Monuron.
CP 50144	Not released yet.
C 6313	N-(4-bromo-3-chlorophenyl)-N'-methoxy N' methyl urea.

DAC 893	Dimethyl 2, 3, 5, 6-tetrachloroterephthalate.
Dicryl	N-(3, 4-dichlorophenyl) methacrylamide.
Diuron	N'-(3, 4-dichlorophenyl)-NN-dimethylurea.
DMPA	0-(2, 4-dichlorophenyl) 0-methyl N-isopropyl phosphoro-amidothioate.
DNBP	2-(1-methylpropyl)-4, 6-dinitrophenol.
DNOC	2-methyl-4, 6-dinitrophenol.
Endothal	7-oxabicyclo (2, 2, 1) heptone -2, 4-dicarboxylic acid.
Esteron Ten Ten	2, 4-Dichlorophenoxyacetic acid propylene glycol butyl ether ester.
Ioxynil	4-hydroxy-3, 5-di-iodobenzonitrile.
IPC	Isopropyl N-phenylcarbamate.
Linuron	N'- (3, 4-dichlorophenyl) -N-methyoxy-N-methylurea.
Monuron	N'-(4-chlorophenyl)-NN-dimethylurea.
Karsil	N-(3, 4-dichlorophy)-2-methylpentanamide.
KOCN	Potassium cyanate.
Prometryne	4, 6-bisisoprapylamino-2-methylthio-1, 3, 5-triazine.
Ramrod	2 Chloro-N-isopropylacetanilide.
Randox - T	3:7.5 mixture of CDAA and trychlorobenzyl chloride.
Simazine	2-chloro-4, 6-bisethylamino-1, 3, 5-triazine.
Sindone	1, 1-dimethyl-4, 6diisopropyl-5-indanyl ethyl ketone.

Solan	N-(3-chloro-4-methylphenyl)-2-methylphentonamide.
Stam F-34	3, 4-dichloropropionanilide.
H_2SO_4	Sulfuric acid.
Tenoran	N-4 (p-schlorophenoxy)-phenyl-N', N'-dimethylurea.
Tok E-25	2, 4-dichlorophenyl-4-nitrophenyl ether.
2, 4-D	2, 4-dichlorophenoxyacetic acid.
2, 4-D amine	Amine salt of 2,4-Dichloro-Phenoxy Acetic acid.
2, 6-DBN	2, 6-dichlorobenzonitrile.
Used motor oil + diesel oil	Mixture of hydrocarbones of the lubricating and kerosene ranges.
Zytron	See DMPA.

Appendix B

Flow Sheet of the Chemical Analysis for Onion Pungency Determination[1]

1. Peel sample to edible tissue.
2. Weigh sample (approximately 25 g).
3. Add 5 times the weight of sample in volume of distilled water.
4. Blend for 2 minutes in a waring blender. (Do not allow to heat).
5. Pour into a beaker. Let it stand for at least 10 minutes.
6. Stir to a homogenous mass (use a glass rod).
7. Weigh 15 g of puree into a tared beaker.
8. Heat to boiling. Wash down immediately with distilled water.
9. Pour into a 200 ml volumetric flask. Make to volume with distilled water.
10. Shake and filter through a Whatman number 1 filter paper.
11. Take an aliquat of 4 ml.
12. Add 2 ml of 0.0125 percent 2, 4-dinitrophenyl hydrazine in 2 N HCl.
13. Place in a water bath at 37 °C for 10 minutes.
14. Add 10 ml of 0.6 N NaOH. Shake.
15. After one hour transfer to a Fisher Electrophotometer Colorimeter.
16. Read against a 420 m μ blue filter.
17. Convert percent absorbtion readings to micromoles of sodium.

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1. By Schwimmer and Weston (1961), and modified by Saghir *et al*. (1964).

pyruvate, using Figure 1.

18. Calculate micromoles of pyruvic acid per one gram of fresh weight as follows:

$$\frac{\mu \text{ moles of sodium pyruvate} \times \frac{88 \text{ (molecular weight of pyruvic acid)}}{110 \text{ (molecular weight of Na pyruvate)}}}{\text{fresh weight of sample}}$$

19. Report enzymatically produced pungency as μ moles of pyruvic acid of the Total minus that of the Blank[1].

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1. For Blank determination: Blanch another sample for five minutes after step 2 and follow the same procedure.

Appendix C

Table 8. Analysis of variance for number of weeds, onion stand and leaf length resulting from pre-emergence applications of herbicides on onions in 1967.

Source of variation	D.F.	M.S.		
		Weeds per sq. meter	Onions per sq. meter	Leaf length
Blocks	2	68.30	19.94	13.34
Treatments	21	32.77	47.57	9.86
Error	42	20.20	75.94	8.51

Table 9. Analysis of variance for number of weeds, onion stand and leaf length resulting from post-emergence applications of herbicides in 1967.

Source of variation	D.F.	M.S.		
		Weeds per sq. meter	Onions per sq. meter	Leaf Length
Blocks	2	78.29	279.12	44.13
Treatments	21	41.28	24.25	10.73
Error	42	25.90	34.89	13.64

Table 10. Analysis of variance for bulb diameter, bulb index and bulb weight resulting from pre-emergence applications of herbicides in 1967.

Source of variation	D.F.	M.S.		
		Bulb diameter	Bulb index	Fresh weight per bulb
Blocks	2	2.31	0.00110	3948.47
Treatments	21	0.35	0.00055	464.12
Error	42	0.34	0.00972	287.26

Table 11. Analysis of variance for bulb diameter, bulb index and bulb weight resulting from post-emergence applications of herbicides in 1967.

Source of variation	D.F.	M.S.		
		Bulb diameter	Bulb index	Fresh weight per bulb
Blocks	2	1.094	0.00395	5480.72
Treatments	21	0.202	0.00028	263.47
Error	42	0.309	0.00152	402.73

Table 12. Analysis of variance for yield and moisture percentage resulting from pre-emergence applications of herbicides on onions in 1967.

Source of variation	D.F.	M.S.	
		Yield	Moisture percentage
Blocks	2	3399272.5	11.099
Treatments	21	608151.8**	2.479
Error	42	37261.2	1.769

** Significant at 1 percent level.

Table 13. Analysis of variance for yield and moisture percentage resulting from post-emergence applications of herbicides on onions in 1967.

Source of variation	D.F.	M.S.	
		Yield	Moisture percentage
Blocks	2	3518989.5	4.128
Treatments	21	833273.9	2.628
Error	42	469198.7	3.180

Table 14. Analysis of variance for total soluble solids and pungency resulting from pre-emergence applications of herbicides on onions in 1967.

Source of variation	D.F.	M.S.	
		Total soluble solids	Pungency
Blocks	2	7.383	4.620
Treatments	21	3.259	0.334
Error	42	3.811	0.324

Table 15. Analysis of variance for total soluble solids and pungency resulting from post-emergence applications of herbicides on onions in 1967.

Source of variation	D.F.	M.S.	
		Total soluble solids	Pungency
Blocks	2	2.732	4.736
Treatments	21	2.761	0.189
Error	42	3.997	0.422