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RESPONSE OF BROAD BEAN (*Vicia faba* L.) TO FOLIAR SPRAY OF DIFFERENT K-SOURCES AND ENERGY RELATED ORGANIC COMPOUNDS (EROC) TO INDUCE BETTER INTERNAL K AND SUGARS CASE TOWARDS BETTER GROWTH AND PRODUCTIVITY

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ABSTRACT

Two field experiments were performed at Mansoura Experimental Farm, Agric. Res. Institute, Cairo, during 2000/2001 and 2001/2002 seasons. To study the effect of foliar spray of different K-sources and EROC and their combinations on growth, chemical composition and yield of El-Kobrosy broad bean to improve the internal K and sugars content and to reduce flowers and small pods abscission problems and maximizing its productivity.

Important results were as follows:-

1. Effect of EROC: The most effective one was ATP and/or glucose those greatly increased tillering, DM accumulation N, P, K and sugars content this was accompanied with the greatest increase in No. of pods and yield of plant and area.
2. Effect of K-sources: Organic K source (K-citrate) was the absolutely best K-source of the most favourable growth, K, sugars and productivity responses.
3. Effect of interaction: The most favourable interactions were K-cit. x ATP followed by K-cit. x glucose and K-cit. x citric acid.
4. Untreated plants exhibited the poorest internal case (K and sugars content), this was paralleled with the least growth and fruiting case, which proved dramatic abscission case.
5. Internal K, non-reducing and total sugars were positively and highly correlatwith No. of pods, K, reducing and total sugars were considerably correlated with pod weight.
6. The foliar application of K and EROC suggested to be a new rapid, easy and cost effective technique for maximizing yield and avoiding climatic and soil stress adverse effects.
7. It could be suggested that P, K and total sugars content of leaves must be taken as a good internal indicator for productivity case, 0.103%, 2.86% and 17.0 mg/gm DW, respectively (critical contents) associated with low productivity case. 0.230%, 5.71% and 42.7 mg/gm, respectively (suitable contents associated with high productivity case.

Finally, it could be concluded that spraying broad bean plants with K-citrate (1.5 gm K / L) and ATP (50 ppm) to improve K and sugars content, increase tillering, and maximize fruiting and productivity.

INTRODUCTION

The abscission of flowers, ovaries and small formed pods of broad bean (*Vicia faba* L.) considered as a serious problem led to the low productivity of such important vegetable crops. The botanical nature of the higher flowering capacity and the interference of different development stages (vegetative, flowering and fruiting), all occurred at the same time.

This led to a dramatic competition among them on the available organic bioconstituents and minerals, which they required. Also, climatic stress of temperature fluctuations and low night temperature prevails at early critical periods. Such conditions adversely affected pod setting and inducing an internal metabolic disturbances, i.e. low energy (ATP) case, reduction in protein and carbohydrate synthesis and severe carbohydrate depletion (Sinclair, 1967; Rabe and Lovatt, 1986; Lyons and Brieden-Bach, 1990 and Ortiz, 1991).

On the other hand, it was reported that legumes including broad bean known to be higher potassium (K) requirements for normal growth and fruiting (Said, 1984 and Tang, 1998). Meanwhile, K known to be involved in energy metabolism processes, protein synthesis and sugars synthesis and translocation (Secer, 1978 and Mengel and Kirkby, 1980).

An argent and early sugars mobilization into floural buds is a highly K and ATP-dependent process and of great importance for fruit setting (Besford and Maw, 1975 and Edmond *et al.*, 1980). Under Egyptian conditions, soil K-status became a problem under question, because its continuous depletion as a result of more intensive cropping, the relatively absence of the compensatory effect of Nile flow, higher K-fixing capacity of old soils. Also, there was some wrong ideas, which regarded some crops including broad bean as a crop of less or no K-need.

Recently, more attention was paid to potassium foliar nutrition (Montance, 1989; El-Habbasha *et al.*, 1996; Abu El-Defan *et al.*, 1999; El-Shabasi and El-Bahr, 1999; El-Ganayni, 2000 and Anton and Ahmed, 2001). Recently, also there was an increasingly intrest to investigate the effect of some promising agents, so called energy related-organic compounds (EROC), i.e. ATP, organic acids (citric), sugars (glucose) and etc. For their bromotional effect on plant energy case, and all biosynthesis processes as well as other fundamental acts, specially during stresses.

The ATP exogenously application was reported by Njoroge *et al.* (1998), Fathy and Farid, 2000 and Fathy *et al.* (2000). Citric acid application as EROC, anti-oxidant and anti-ethylene (Darwish and Ahmed, 1992; Elad, 1992; Sarkar and Jones, 1992; Mansour *et al.*, 1998 and Chen *et al.*, 1999). Sugars (glucose) as EROC and for fruiting improvement (Besford and Maw, 1975; Lascaris and Deacon, 1991; Agwah and Mahmoud, 1994 and El-Desouky *et al.*, 2000).

Present work aimed to be improved broad bean plant internal K, sugars and energy status to reduce the incidence of flowers and pods abscission thereby maximizing its productivity. This by foliar nutrition with K from different sources and with energy related organic compounds.

MATERIALS AND METHODS

Two field experiments were conducted at Experimental Station (Mansoura), Hort. Res. Inst., during two successive winter seasons of 2000/2001 and 2001/2002.

To study the effect of different K-sources, different energy related organic compounds (EROC) and their combinations (all were foliar applied) on growth, chemical composition, yield and its components of broad bean (*Vicia faba* L.) plants. On October 1st, seeds of broad bean El-Kobrosy cv. were sown on one side ridge (5 m long and 0.6 m width), 20 cm apart. Each plot contained 4 ridges (12 m^2 area).

Split plot design was adopted, the EROC, i.e. ATP, citric acid and glucose added to control were in main plots, the different 7 K-sources plus control were in sub-plots. The experiment was 4 x 8 treatments, replicated 3 times.

Treatments:

Energy related organic compounds (EROC):

ATP (Adenosine triphosphate) (50 ppm).
Citric acid (5 gm/L).
Glucose (10 gm/L).

Potassium sources:

K_2SO_4 (42% K), K_2CO_3 (52.0% K), KH_2PO_4 (30% K), KOH (70% K), KNO_3 (36% K), K-cit. ($K_3C_6H_5O_7$ – 38% K), KCL (50% K). Potassium from different sources was used at the same concentration (1.5 gm K / L).

EROC were foliar applied 3 times at the beginning of flowering and repeated each 3 weeks. K-foliar application began just before flowering and applied again 3 times with 3 weeks intervals.

Experiment parameters:

After 105 days from sowing, representative plant samples were taken from each plot for determination of plant height (cm), No. of tillers / plant, fresh weight (FW) and dry weight (DW) (gm) / plant. At the same time, N, P and K contents of leaves were determined at dry weight basis according to Homeck and Hanson (1998) and Homeck and Miller (1998).

Carbohydrate was extracted according to method of Said and Nageib (1964) and determined according to method of Michel *et al.* (1956), also the total sugars was determined by the same method. Reducing sugars was determined according to methods of Miller (1959), non-reducing sugars was calculated from total sugars submitted by reducing sugars.

Yield and its components:

Pods number and weight were recorded from the cumulative harvesting allover the season at the plot basis. Then, all yield and yield components were calculated and determined.

Data of soil analysis and air temperatures were presented herein.

These indicating the prevails of climatic (low and fluctuated night temperatures), soil (low potassium K-content) stresses during the two seasons of this work.

Mechanical and chemical analysis of experimental soils.

Soil properties	2000/ 2001	2001/ 2002	Soil properties	2000/ 2001	2001/ 2002
Coarse sand (%)	1.50	1.63	Total N (%)	0.13	0.14
Fine sand (%)	22.00	21.47	Available P (ppm)	7.15	7.95
Silt (%)	25.33	26.88	Exchangeable K (ppm)	215.00	201.00
Clay (%)	49.60	49.13	pH	7.90	8.02
O.M. (%)	1.90	2.10			

Monthly means of night temperature during 2000/2001 and 2001/2002 seasons.

Months	2000 / 2001	2001 / 2002
November	14.4	13.2
December	11.5	9.7
January	9.4	7.3
February	10.4	11.1
March	9.5	12.1
April	12.2	12.1
May	16.3	15.7

RESULTS AND DISCUSSION

I. Effect of energy-related organic compounds (EROC):

I.1. Vegetative growth:

Data of Table (1) indicated that application (foliar spraying) of (EROC) ATP, citric acid and glucose were significantly stimulated all growth parameters (plant height, number of tillers, fresh and dry weight) of broad bean plant compared with those of non-treated plants at both seasons.

Table 1: Effect of EROC on growth of broad bean during two seasons.

Character treated (EROC)	Plant height (cm)	No. of tillers / plant	Fresh weight / plant (gm)	Dry weight / plant (gm)	Plant height (cm)	No. of tillers / plant	Fresh weight / plant (gm)	Dry weight / plant (gm)
	2000/2001 season				20001/2002 season			
ATP	144.5b	19.30a	1351.0a	249.3a	147.8b	19.80a	1377.0a	257.4 a
Citric acid	153.1a	17.50 b	1265.0c	232.3c	156.4a	17.50 b	1298.0c	239.1 c
Glucose	144.4b	16.90 c	1310.0b	242.0b	147.8b	17.20 b	1325.0b	244.4 b
Control	130.5c	13.70 d	963.3 d	174.1d	133.2c	14.40 c	975.2d	176.8 d

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

The most superior effect was of ATP followed by glucose and at least citric acid with considerable differences among them in most cases. The unique exception was the greatest value of plant height of citric acid treatment relative to other ones at two seasons.

Such results were coincided by those of Niorage *et al.* (1998), Fathy and Farid (2000), Fathy *et al.* (2000), dealing with ATP application, Darwish and Ahmed (1997), Mansour *et al.* (1998), dealing with citric acid, Agwah and Mahmoud (1994)and El-Desouky *et al.* (2000), with sugar.

Herein, the marked promotional effect of ATP, glucose and citric acid treatments on tillering and dry matter accumulation of broad bean plants under present work conditions could be expected, since the same treatments were similarly induce higher N, P, K, sugars and carbohydrates content of their plants (Table 2). This might be due to their enhancing effect on energy synthesis and status, which indicated by P and sugars content (Table 2) via glycolysis and TC-cycle respiratory pathways. Thereby activation of all bio-constituents formation (Mengel and Kirkby, 1980), then accumulation of dry matter and best growth. Also, ATP known to be act as cytokinin via its hydrolytic AMP, the main precursor of cytokinin (Jameson, 1994), this might be induced best tillering.

Additionally, citric acid and other organic acids known to be involved via transamination in amino acids formation, it is also act as anti-ethylene and anti-oxidant, in turn increased cell viability and delayed senescence (Sarker and Jones, 1992; Chen *et al.*, 1999 and Elad, 1999), those might be beneficially extended to growth activities. On the other hand, the pronounced restriction in growth of control plants could be attributed with the internal physiological and biochemical status of such plants (lowest energy and biosynthesis activities) indicated by the lowest N, P, K, sugars and carbohydrates content (Table 2).

Such occurrences might be attributed with the effect of the stressful temperature (previously presented), those expected to be induced (low energy case, low protein synthesis and great carbohydrate depletion) and at least growth inhibition (Sinclair, 1967; Rabe and Lovatt, 1986; Lyons and Briedenbach, 1990 and Ortiz, 1991). Moreover, the botanical nature of this crop of the severe competition among vegetative and reproductive parts on minerals and bio-metabolites at the same time could be associated too.

I.2. Minerals and bio-constituents:

Data in Table (2) showed that all the applied EROC were greatly increased N, P, K, reducing, non-reducing, total sugars and total carbohydrates content compared with those of control plants at two seasons. Same data indicated that the highest N, P and K content were of ATP followed by citric acid treatment. Glucose followed also by citric acid were of the highest sugars and carbohydrates, all at both seasons.

ATP-treated plants might be respired more sugars and carbohydrates for more growth and reproductive activities. At the same time activated H^+-ATP-ase membrane pumps, the key site responsible for minerals uptake and translocation as well as organic solutes translocation (Palta, 1990).

Glucose application seemed to be sustained the internal sugars content and reasonably maintained higher sugar and carbohydrates content. Citric acid gave medium effect, this might be due to it is not a direct energy or sugar substances.

I.3. Yield and its components:

The data presented in Table (3) illustrated that all treatments were significantly superiored control one in number of pods / plant, pod average weight, seeds, weight / pod, yield / plant and plot, but less differences were detected among them in pod length and diameter at both seasons.

The highest yield of plant and plot were of glucose followed by ATP and by citric acid treatments, this mainly due to their effect on number of pods in the same trend and somewhat pod weight average. Such effects could be also attributed with their effect on growth, mineral composition and sugars content (Tables 1 & 2), also due to all the above mentioned considerations.

In addition, sugars known to be directly involved and required in early stages for fruit setting activities (Emmert, 1961, Besford and Maw, 1975 and Lasçaris and Deacon, 1991). Besides, ATP induce more beneficial effect via its implication in gene (DNA) structure and function (expression) (MaClure *et al.*, 1989 and Dashek, 1997).

II. Effect of different K-sources:

II.1. Vegetative growth:

Broad bean as other legumes known to be of higher K-requirements for normal growth and fruiting (Said, 1984 and Tang, 1988). Recently, under Egyptian conditions, soil-K status and K-nutrition became a problem under question (El-Deeb, 1990 and El-Ganayani, 2000). Notice, the prior soil analysis, which proved the soil low available K content.

The data in Table (4) confirmed such considerations and indicated that all the foliar applied K-sources were significantly induce higher values of vegetative growth traits compared with control and were significantly differed among them in most cases at two seasons. The most favorite K-source of the supriorest effect was K-citrate followed by KCl and by KNO_3 and K_2SO_4. These clear differences among such K-sources could be due to their different effects on K content of their plant tissues as well as N, P, sugars and carbohydrates (Table 5). Also, might be due to the differences in the K-complementary ions (citrate, Cl^-, NO_3^- and $SO_4^{=}$), thereby their metabolic activation and implication. Once again, the superiority of K-citrate could be attributed with its capacity to supplying and establishing best K status within plant tissues and with the favourable effect of its complementary citrate organic ion. Control plants gave the lowest growth parameters due to their poor internal minerals and sugars content (Table 5).

Herein it is of benefit to be referred to the important functions and involvement of K, which reflected on growth case, i.e. energy metabolism, protein and sugars synthesis and translocation, enzyme activation and cell enlargement (Secer, 1978 and Mengel and Kirkby, 1989). Similar results were obtained by Montance (1989), El-Habbasha *et al.* (1996); Tang (1998)Abou El-Defan *et al.* (1999); El-Shabasi and El-Bahr (1999) and El-Ganayni (2000).

Table 2: Effect of EROC on chemical composition of broad bean during two seasons.

Character treated (EROC)	N(%)	P(%)	K(%)	Red. Sugars (mg/ gm DW	Non-Red. Sugars (mg/ gm DW	Total sugars (mg/ gm DW	Total Carbo-Hydrate (mg/ gm DW	N(%)	P(%)	K(%)	Red. Sugars (mg/ gm DW	Non-Red. Sugars (mg/ gm DW	Total sugars (mg/ gm DW	Total Carbo-Hydrate (mg/ gm DW
	2000/2001 season							20001/2002 season						
ATP	2.55ab	0.188a	5.03 a	3.22 b	25.44c	28.66c	551.9c	2.60ab	0.192a	5.08 a	3.32 b	26.50c	29.87c	569.2 c
Citric acid	2.53 b	0.157b	4.74 b	2.81 c	28.00b	30.81b	588.1b	2.56 b	0.161b	4.85 a	2.83 c	28.90b	31.73b	585.9 b
Glucose	2.56 a	0.143c	4.26 c	4.52 a	31.41a	35.93a	616.1a	2.66 a	0.145c	4.48 b	4.64 a	33.05a	37.65a	617.8 a
Control	2.10 c	0.124d	3.66 d	2.39 d	20.72d	23.11d	462.1d	2.16 c	0.125d	3.89 c	2.44 d	21.25d	23.70d	467.8 d

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

Table 3: Effect of EROC on yield and its components of broad bean during two seasons.

Character treated (EROC)	No. of pods / plant	Average Pod Weight (gm)	Yield / plant (gm)	Yield / plot (kg)	Seeds weight / pod (gm)	Pod length (cm)	Pod Diam-eter (cm)	No. of pods / plant	Average Pod Weight (gm)	Yield / plant (gm)	Yield / plot (kg)	Seeds weight / pod (gm)	Pod length (cm)	Pod Diam-eter (cm)
	2000/2001 season							20001/2002 season						
ATP	50.17 b	23.81 a	1193 b	119.3 b	14.80 a	17.24 a	2.04 a	51.21b	23.84 a	1217 b	121.7b	15.06a	17.43a	2.15 a
Citric acid	49.58 c	23.43 b	1163 c	116.3 c	13.9 b	17.10 a	1.98 ab	50.63b	23.46 a	1187 c	119.0c	14.18b	17.23b	2.06bc
Glucose	54.04 a	23.94 a	1296 a	129.6 a	13.1 c	17.25 a	2.05 a	54.79a	24.07 a	1320 a	132.0a	13.30c	17.47a	2.12ab
Control	35.54 d	22.41 c	800.3 d	80.03 d	11.1 d	17.24 a	1.93 b	36.08c	22.56 b	817.6d	81.7 d	11.32d	17.34ab	2.00 c

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

Table 4: Effect of different K-sources on growth of broad bean during two seasons.

K Sources	Plant height (cm)	No. of tillers / plant	Fresh weight / plant (gm)	Dry weight / plant (gm)	Plant height (cm)	No. of tillers / plant	Fresh weight / plant (gm)	Dry weight / plant (gm)
	2000/2001 season				20001/2002 season			
K_2SO_4	148.8 b	17.00 c	1278.0 c	230.1 c	152.9 c	17.75 b	1297.0 c	238.3 c
K_2CO_3	141.0 d	15.90 d	1204.0 e	220.7 d	144.8 e	16.08 d	1229.0 d	226.1 d
KH_2PO_4	144.3 c	15.20 e	1095.0 g	201.2 e	146.6 d	16.00 d	1126.0 f	207.2 f
KOH	144.4 c	16.70 c	1164.0 f	218.1 d	146.2 de	16.67 c	1180.0 e	218.0 e
KNO_3	139.1 e	16.60 c	1324.0 b	243.3 b	142.0 f	16.75 c	1331.0 b	248.3 b
K-citrate	158.0 a	24.70 a	1750.0 a	322.1 a	163.3 a	25.50 a	1792.0 a	330.1 a
KCl	158.4 a	18.20 b	1219.0 d	224.1 cd	160.8 b	18.17 b	1232.0 d	227.2 d
Control	111.0 e	10.60 f	743.6 h	135.9 f	113.8 g	11.50 e	762.9 g	140.2 g

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

Table 5: Effect of different K-sources on chemical composition of broad bean during two seasons.

K Sources	N(%)	P(%)	K(%)	Red. Sugars (mg/ gm DW	Non-Red. Sugars (mg/ gm DW	Total sugars (mg/ gm DW	Total Carbo-Hydrate (mg/ gm DW	N(%)	P(%)	K(%)	Red. Sugars (mg/ gm DW	Non-Red. Sugars (mg/ gm DW	Total sugars (mg/ gm DW	Total Carbo-Hydrate (mg/ gm DW
	2000/2001 season							20001/2002 season						
K_2SO_4	2.50 c	0.140 c	4.63 c	4.23 b	27.80 c	32.03 c	530.3 e	2.56 b	0.143 c	5.07 ab	4.30 b	28.33 c	32.63 c	554.1 d
K_2CO_3	2.43 d	0.148 c	4.53 d	4.43 a	23.80 g	28.23 e	603.6 b	2.49bc	0.151 c	4.66 c	4.63 a	24.46 e	29.19 e	607.4 b
KH_2PO_4	2.25 f	0.141 c	4.35 f	3.53 c	25.73 e	29.26 d	494.9 f	2.33 d	0.143 c	4.47 c	3.59 c	27.15 d	30.74 d	499.3 f
KOH	2.34 e	0.139 c	4.49 e	3.32 d	26.58 d	29.90 d	540.7 d	2.38 d	0.141 c	4.57 c	3.40 d	27.27 d	30.67 d	540.8 e
KNO_3	2.79 a	0.147 c	4.36 f	2.30 f	24.38 f	26.68 f	481.1 g	2.83 a	0.150bc	4.71 c	2.40 f	24.69 e	27.09 e	485.0 g
K-citrate	2.76 b	0.205 a	5.27 a	3.13 e	33.21 a	36.34 a	694.6 a	2.82 a	0.208 a	5.31 a	3.12	34.74 a	37.86 a	696.9 a
KCl	2.43 d	0.191 b	4.78 b	3.35 d	31.76 b	35.11 b	593.4 c	2.47 c	0.196ab	4.79 bc	e3.34 d	32.97 b	36.31 b	597.3 c
Control	1.98 g	0.113 d	2.94 g	1.56 g	18.21 h	17.77 g	498.1 f	2.06 e	0.116 c	3.01 d	1.62 g	19.05 f	20.67 g	500.0 f

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

II.2. Minerals and bio-constituents:

Data in Table (5) revealed that K-citrate was of the significant highest mineral, sugars and carbohydrates content except reducing sugars compared with all treatments at two seasons.

The other K-sources (KCl and K_2SO_4) were significantly increased N, P, K, total sugars and its fraction as well as total carbohydrates compared with control. Also, KCl and K_2SO_4 were of considerable beneficial effect during the two seasons.

Also, K_2CO_3, KNO_3, KOH and KH_2PO_4 were of beneficial effect and varied among them in their effect on different chemical contents. Such diversed responses of broad bean plants to different potassium (K) sources dealing with their minerals and sugars content might be associated with the effect of their different companion ions, citrate might be enhanced the energy metabolism and amino acid synthesis and it is favourate as an organic K-source. KCl responses indicated that broad bean to some extent had a Cl-philicity nature.

In addition, NO^-_3, $CO^=_3$, $PO^≡_4$, $SO^=_4$ ions might be of metabolic supportable effects due to their involvement in N-assimilation, carpohydrate synthesis, P-assimilation, energy generation, S-assimilation, and amino acids formation, respectively. Besides their effects on internal pH status. Such results and interpretation were confirmed by those of Montance (1989), foliar K_2SO_4; El-Shabashi and El-Bahr (1999), foliar KCl and KNO_3.

Once again, such different K-sources were greatly differed in their capacity to ensure suitable K supply and content, although they were used at the same K concentration. This resulted also in different growth and yield responses (Table 4 and 6). Potassium known to be of indispensable functions in plant metabolism (Secer, 1978 and Mengel and kirkby, 1980).

II.3. Yield and its components:

Data of Table (6) showed that broad bean plants, which received no K-supply (control) were significantly of the lowest pods number and weight as well as lowest weight of seeds / pod. Thereby the lowest yield of plant and plot during two seasons. This could be logically true, since such plants were of the least growth (tillering and dry matter content and least N, P, K and sugar content) (Tables 4 and 5), those which tightly related with number and weight of pods (Table 10).

In contrary, all the applied K-sources were of the best yield and yield components compared with control during the two seasons. The favourable K-sources of the highest plant and plot yield were K-citrate followed by KCl, also K_2SO_4 and K_2CO_3 were equally of beneficial effect with less differences among them. Such yield improvement was due to the increase in pods number rather than pods weight as affected by different K-sources. Herein it could be attributed such effects with K and sugars content (Table 5), as well as growth case (Table 4), also correlation data (Table 10) were confirmed these relations.

Table 6: Effect of different K-sources on yield and its components of broad bean during two seasons.

K Sources	No. of pods / plant	Average Pod Weight (gm)	Yield / plant (gm)	Yield / plot (kg)	Seeds weight / pod (gm)	Pod length (cm)	Pod Diameter (cm)	No. of pods / plant	Average Pod Weight (gm)	Yield / plant (gm)	Yield / plot (kg)	Seeds weight / pod (gm)	Pod length (cm)	Pod Diameter (cm)
	2000/2001 season							20001/2002 season						
K_2SO_4	48.2 b	23.8 b	1150 c	115.0 c	12.74 d	18.35 a	1.96 b	49.17 b	23.70bc	1176 c	118.0 c	12.94 d	18.56 a	2.12abc
K_2CO_3	46.7 c	23.9 b	1122 d	112.2 d	13.57 b	18.24 a	2.02 ab	47.42 c	24.08 b	1145 d	114.5 d	13.78 b	18.38 b	2.09 bc
KH_2PO_4	44.5 e	23.7 b	1058 e	105.9 e	12.52 e	16.30 e	2.10 a	45.33 d	23.81 b	1083 e	108.3 e	12.73 e	16.50 d	2.19 a
KOH	45.6 d	24.4 a	1125 d	112.5 d	13.61 b	16.91 d	2.02 ab	46.17 d	24.71 a	1148 d	114.8 d	13.86 b	17.10 c	2.04 cd
KNO_3	44.2 e	23.1 c	1024 f	102.4 f	13.25 c	16.30 d	1.84 c	45.17 d	23.21 c	1046 f	104.6 f	13.51 c	16.95 c	1.91 e
K-citrate	67.3 a	22.7 d	1522 a	152.2 a	16.48 a	17.15 c	2.02 ab	68.67 a	22.57 d	1549 a	154.9 a	16.75 a	17.10 c	2.17 ab
KCl	48.6 b	24.0 b	1180 b	118.0 b	13.63 b	18.02 b	2.01 ab	49.08 b	24.10 b	1194 b	119.4 b	13.84 b	18.26 b	2.11abc
Control	33.3 f	21.5 e	721 g	72.1 g	10.08 f	15.88 f	1.98 ab	34.42 e	21.68 e	744 g	74.4 g	10.31 f	16.06 e	2.00 b

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

Furthermore, K known to be greatly implicated in bud differentiation and flowering (Edmond *et al.*, 1981), and in flowering and fruit setting (Fathy *et al.*, 2000). Also, more sugar supply to the floral buds known to be required for best fruiting and yield (Emmert, 1961 and Besford and Maw, 1975). Similar results were obtained by Said (1984) and El-Ganayni (2000)

III. Effect of interaction (EROC x K-sources):

III.1. Vegetative growth:

Data in Table (7) indicated that all interaction treatments were significantly improved all growth traits compared with all control treatments and also were varied among them at two seasons. The most effective treatments which greatly increased tillering and dry matter accumulation were K-citrate x ATP followed by K-citrate x citric acid K-citrate x glucose with significant differences among them at both two seasons. Control x ATP, glucose and citric acid were superiored control x control one. Herein, the superior effect of K-citrate x ATP, citric acid and glucose interactions could be attributed with their similar effect on minerals and sugars content (Table 8) and with the effect of their individual factors (Tables 1, 2, 4 and 5). Meanwhile, data of correlation (Table 10) coincided such relations. Results of Darwish and Ahmed (1997), El-Shabasi and El-Bahr (1999), El-Desouky *et al.* (2000), El-Ganayni (2000) and Fathy and Farid (2000) were confirmed the present results.

III.2. Minerals and bio-constituents:

All interactions were considerably improved N, P, K and sugars content and broad bean plants compared with control (of the lowest contents) (Table 8). K-citrate x ATP was the treatment of the highest N, P and K content, K-citrate x glucose was of the highest non-reducing and total sugars, K_2SO_4 x glucose was of the highest reducing sugars and KCl x citric acid was of the highest total carbohydrates at two seasons. It was noticed that the treatments of the best K, non-reducing and total sugars were also of the best tillering, number of pods and total yield (Tables 7 and 9). Their effect could be related with the effect of their individual factors (Tables 2 and 5).

III.3. Yield and its components:

Data in Table (9) revealed that K-citrate x ATP, K-citrate x citric acid and K-citrate x glucose were respectively the most superior treatments of the highest number of pods / plant, seeds weight / pod, yield of plant and area (plot) at two seasons. KOH x ATP and glucose were of the highest pod average weight. In contrary, control plants (control x control) were markedly of the least yield and yield components. This due to their low tillering capacity, low K and sugars content and poor energy case indicated by low (P and sugars) content (Tables 7, 8 and 10). Such status reflected the incidence of dramatic flowers and small pods abscission, which associated with broad bean botanical nature, this which aggravated by the soil-K and climatic prevails stressful conditions (previously presented).

Table 7: Effect of different K-sources x EROC interaction on growth of broad bean during two seasons.

EROC	K sources	Plant height (cm)	No. of tillers / plant	Fresh weight / plant (gm)	Dry weight / plant (gm)	Plant height (cm)	No. of tillers / plant	Fresh weight / plant (gm)	Dry weight / plant (gm)
		2000/2001 season				20001/2002 season			
ATP	K_2SO_4	140.0 jk	17.67 gh	1275.0 i	232.3 fgh	144.3 jkl	18.33 g	1302.0 i	241.0 h
	K_2CO_3	143.7 h	16.00 jk	1228.0 jkl	227.7 gh	147.3 ij	16.33 jklm	1252.0 jk	232.0 ij
	KH_2PO_4	141.0 j	15.3 klm	1149.0 m	212.7 ij	144.7 jk	15.67 lmn	1210.0 kl	223.7 k
	KOH	139.7 jk	18.67 f	1390.0 f	257.0 de	139.7 no	19.33 f	1413.0 fg	263.7 f
	KNO_3	147.7 g	18.00 fg	1401.0 ef	259.0 de	152.7 g	18.00 gh	1362.0 h	265.7 f
	K-cit.	160.3 d	30.33 a	2100.0 a	399.3 a	166.0 e	32.00 a	2230.0 a	413.7 a
	KCl	174.0 a	26.33 c	1420.0 e	261.7 d	174.3 b	26.00 c	1441.0 ef	268.0 ef
	Control	109.7 q	12.33 p	782.7 u	144.7 qr	113.7 t	12.67 pq	808.7 t	146.3 s
Citric acid	K_2SO_4	163.3 c	16.67 ij	1426.0 e	261.3 d	168.3 de	17.00 hijk	1440.0 ef	264.3 f
	K_2CO_3	144.0 h	16.67 ij	1358.0 g	246.0 ef	149.0 hi	16.67 ghij	1388.0 gh	255.0 g
	KH_2PO_4	167.7 b	15.32 klm	1094.0 n	200.7 jk	171.0 cd	17.33 ghij	1123.0 m	206.7 m
	KOH	148.0 g	17.30 ghi	1083.0 n	199.3 jkl	150.7 gh	15.33 mno	1107.0 mn	204.0 m
	KNO_3	145.0 h	17.33 ghi	1415.0 ef	261.0 d	146.7 ij	17.33 ghij	1480.0 e	272.7 e
	K-cit.	168.0 b	28.33 b	1680.0 c	309.7 c	174.0 bc	28.67 b	1775.0 c	327.0 c
	KCl	175.3 a	17.33 ghi	1307.0 h	241.0 fg	177.7 a	17.33 ghij	1300.0 i	240.3 h
	Control	113.7 p	11.30 q	755.0 v	139.3 r	115.0 st	12.33 q	770.0 t	142.3 t
Glucose	K_2SO_4	157 0 f	20.33 e	1550.0 d	271.3 d	156.0 f	21.33 e	1583.0 d	292.0 d
	K_2CO_3	136.3 lm	16.00 jk	1203.0 l	223.3 hi	140.3 mn	16.33 jklm	1245.0 jk	230.0 ij
	KH_2PO_4	138.3 kl	15.67 kl	1140.0 m	211.0 ij	141.3 lmn	16.00 klmn	1172.0 l	218.3 l
	KOH	154.3 e	17.00 hi	1217.0 kl	240.7 fg	157.0 f	17.67 ghi	1218.0 jk	224.0 k
	KNO_3	143.3 hi	16.00 jk	1427.0 e	262.7 d	144.3 jkl	15.67 mn	1417.0 fg	262.0 f
	K-cit.	162.3 cd	24.67 d	1927.0 b	355.3 b	189.0 d	23.67 d	1907.0 d	251.3 b
	KCl	154.0 d	16.00 jk	1245.0 j	229.7 gh	156.7 f	16.00 klmn	1265 ij	234.0 f
	Control	115.3 p	10.0 r	773.3 uv	142.0 qr	117.7 c	11.00 r	790.0 t	145.3 st
Control	K_2SO_4	140.7 jk	13.33 o	860.o t	155.3 pq	143.0 klm	14.33 o	863.3 s	156.0 r
	K_2CO_3	140.0 jk	15.00 lm	1027.0 p	185.7 lmn	142.7 klm	15.00 no	10.32 op	187.3 o
	KH_2PO_4	130.3 n	14.67 mn	998.3 q	180.3 mn	129.3 q	15.00 no	998.3 pq	182.0 op
	KOH	135.7 m	14.00 no	965.0 r	175.3 no	137.3 op	14.33 o	980.0 q	178.3 p
	KNO_3	120.3 o	15.00 lm	1053.0 o	190.3 klm	124.3 r	16.00 ghi	1067.0 no	193.0 n
	K-cit.	141.3 ij	15.67 kl	1235.o jk	224.0 hi	145.0 jk	17.67 ghi	1257.0 ijk	227.7 jk
	KCl	130.3 n	13.33 o	905.0 s	164.0 op	134.7 p	13.33 b	921.7 r	166.3 q
	Control	105.3 r	9.00 s	663.3 w	117.7 s	109.0 u	10.00 c	683.3 u	123.7 u

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

Table 8a: Effect of K-sources x EROC on chemical composition of broad bean during first seasons.

EROC	K sources	N (%)	P (%)	K (%)	Reduced Sugars (mg/gm DW)	Non-Reduced Sugars (mg/gm DW)	Total sugars (mg/ gm DW)	Total Carbohydrate (mg/gm DW
		2000/2001 season						
ATP	K_2SO_4	2.46 ij	0.150 fghi	5.03 gh	2.67 j	25.90 j	28.57 ij	453.1 prk
	K_2CO_3	2.43 j	0.161 efg	4.81 i	5.17 cd	21.97 m	27.30 jk	469.2 nop
	KH_2PO_4	2.22 n	0.175 def	4.89 i	3.50 h	21.73 m	25.20 lm	550.7 ij
	KOH	2.57 fg	0.183 de	5.43 d	4.67 fg	25.13 j	29.30 hi	591.8 g
	KNO_3	3.01 b	0.206 cd	5.17 ef	2.10 l	23.10 L	25.20 lm	480.6 no
	K-cit.	3.04 ab	0.258 a	6.17 a	4.13 fg	32.07 fg	37.53 de	762.1 c
	KCl	2.66 pq	0.241 ab	5.69 c	2.47 jk	34.87 cd	35.67 fg	576.8 gh
	Control	2.02 def	0.131 ghijkl	3.00 r	1.47 m	18.73 o	20.20 qr	531.3 kl
Citric acid	K_2SO_4	2.61def	0.136 ghijk	5.10 fg	5.00 d	15.90 j	30.43 h	487.7 n
	K_2CO_3	2.78 c	0.183 de	5.37 d	3.00 i	31.30 g	34.30 g	717.9 d
	KH_2PO_4	2.40 jk	0.134 ghijkl	4.42 jk	4.10 fg	25.67 j	29.77 hi	463.8 opq
	KOH	2.31 lm	0.121 ijkl	4.42 k	1.57 m	27.78 i	29.43 hi	416.3 t
	KNO_3	2.81 c	0.135 ghijk	4.49 jk	1.10 no	29.33 h	30.37 h	460.0 pq
	K-cit.	2.67 d	0.224 bc	5.97 d	2.50 jk	33.70 e	36.20 ef	812.5 b
	KCl	2.61 ef	0.218 bc	5.14 ef	4.00 g	32.00 fg	36.00 ef	839.7 a
	Control	2.05 pq	0.110 kl	3.62 r	1.23 n	18.20 cb	19.37 r	507.2 m
Glucose	K_2SO_4	3.03 ab	0.159 efgh	4.99 h	6.37 a	37.47 b	43.83 b	627.2 f
	K_2CO_3	2.49 hi	0.128 ghijkl	3.97 l	5.57 b	23.03 L	26.60 kl	656.5 e
	KH_2PO_4	2.30 m	0.130 ghijk	4.10 m	4.50 e	34.10 de	38.60 cd	516.3 lm
	KOH	2.36 kl	0.134 ghijk	4.30 l	4.03 fg	35.77 c	39.80 c	719.8 d
	KNO_3	3.07 a	0.126 hijkl	4.97 m	3.60 h	26.07 j	29.67 hi	551.7 ij
	K-cit.	2.81 c	0.200 cd	5.21 e	4.23 f	41.63 a	45.87 a	748.5 c
	KCl	2.45 ij	0.157 efgh	4.51 j	5.27 c	32.73 f	38.00 d	539.1 jk
	Control	2.00 q	0.110 kl	2.90 s	2.60 jk	20.50 n	23.10 o	570.0 hi
Control	K_2SO_4	1.92 r	0.115 jkl	3.41 q	2.90 i	21.90 m	24.80 mn	553.3 ij
	K_2CO_3	2.03 pq	0.121 ijkl	3.99 n	4.00 g	18.90 o	22.90 op	570.6 hi
	KH_2PO_4	2.07 p	0.125 hijkl	4.01 mn	2.03 l	21.40 mn	23.43 no	448.7 prs
	KOH	2.13 o	0.121 ijkl	3.81 o	3.53 h	17.53 p	21.07 q	434.7 rst
	KNO_3	2.28 m	0.123 ijkl	3.71 p	2.40 k	19.03 o	21.43 pq	432.0 st
	K-cit.	2.52 gh	0.140 ghijk	3.75 op	1.63 m	24.13 k	25.77 klm	455.5 pq
	KCl	2.00 q	0.146 fghij	3.76 op	1.67 m	27.43 i	29.10 hi	418.2 k
	Control	1.86 s	0.100 l	2.85 s	0.97 o	15.40 q	6.37 s	383.9 u

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

Table 8b: Effect of K-sources x EROC on chemical composition of broad bean during second seasons.

EROC	K sources	N (%)	P (%)	K (%)	Reduced Sugars (mg/gm DW)	Non-Reduced Sugars (mg/gm DW)	Total sugars (mg/ gm DW)	Total Carbohydrate (mg/gm DW
		2001/2002 season						
ATP	K_2SO_4	2.47 hijkl	0.158 abcd	5.16 cdef	2.90 jk	26.47 jk	29.37 jk	563.5 j
	K_2CO_3	2.53 fghij	0.166 abcd	4.90 cdefgh	5.33 c	22.90 mno	28.57 k	470.3 o
	KH_2PO_4	2.310 lmn	0.180 abcd	5.00 cdefg	3.60 i	23.17 mno	26.77 L	560.0 jk
	KOH	2.60 fgh	0.184 abcd	5.40 bcd	4.67 gh	26.13 jkl	30.20 hij	595.0 h
	KNO_3	3.06 bc	0.207 abcd	5.25 cde	2.37 m	22.60 no	24.97 m	488.4 n
	K-cit.	3.13 b	0.261 a	6.18 a	4.30 efg	35.10 de	39.40 o	766.0 c
	KCl	2.70 ef	0.248 ab	5.67 abc	2.47 lm	36.27 cd	38.70 o	568.3 i
	Control	2.03 op	0.139 cd	3.07 mno	1.57 o	19.40 p	20.97 op	532.3 L
Citric acid	K_2SO_4	2.69 ef	0.139 cd	5.25 cde	5.00 d	26.17 jkl	31.00 gh	462.3 op
	K_2CO_3	2.83 de	0.186 abcd	5.40 bcd	3.13 j	31.83 gh	35.07 f	722.5 o
	KH_2PO_4	2.49 hijk	0.137 cd	4.51 efghijk	4.20 fgh	26.60 jk	30.80 ghi	468.7 o
	KOH	2.35 klmn	0.125 cd	4.50 efghijk	1.70 o	28.30 ij	29.93 hij	421.7 s
	KNO_3	2.69 ef	0.140 cd	4.63 defghi	1.00 q	30.40 hi	31.40 g	456.7 pq
	K-cit.	2.67 efg	0.227 abc	6.07 ab	]2.37 m	36.97 bcd	39.33 d	800.7 b
	KCl	2.62 fgh	0.227 abc	5.30 cde	4.00 h	32.70 fg	36.70 e	833.7 a
	Control	2.12 op	0.112 d	3.97 mnop	1.23 p	18.50 pqr	19.73 p	521.3 m
Glucose	K_2SO_4	3.09 b	0.160 abcd	5.13 cdef	6.60 a	38.57 b	45.07 b	630.3 g
	K_2CO_3	2.58 fgh	0.130 cd	4.67 ijkl	5.77 b	24.10 lmno	29.80 ij	660.2 f
	KH_2PO_4	2.36 jklm	0.131 cd	4.25 ghijkl	4.50 e	36.37 bcd	40.87 c	520.7 m
	KOH	2.40 ijklm	0.136 cd	4.39 fghijkl	4.20 fgh	37.63 bc	41.83 c	708.4 e
	KNO_3	3.28 a	0.128 cd	5.17 cdef	3.77 i	26.37 jkl	30.13 hij	554.3 jk
	K-cit.	2.91 cd	0.200 abcd	5.27 cde	4.33 ef	42.20 a	48.53 a	758.0 c
	KCl	2.50 ghijk	0.160 abcd	4.60 defghij	5.27 c	34.10 ef	39.37 d	550.3 k
	Control	2.12 op	0.111 d	3.00 on	2.70 kl	25.07 klm	24.40 m	560.0 jk
Control	K_2SO_4	1.98 p	0.117 cd	4.76 defghi	3.00 j	22.10 o	25.10 m	560.3 jk
	K_2CO_3	2.04 op	0.120 cd	4.27 ghijkl	4.30 efg	19.00 pq	23.30 n	570.3 i
	KH_2PO_4	2.17 no	0.124 cd	4.10 hijkl	2.67 n	22.47 no	24.47 m	448.0 pq
	KOH	2.18 no	0.118 cd	4.00 ijkl	3.63 i	17.00 qr	20.63 pp	438.3 r
	KNO_3	2.30 mn	0.124 cd	3.81 jklm	2.47 m	19.40 p	21.87 o	441.7 r
	K-cit.	2.57 fghi	0.145 bcd	3.72 klmn	1.50 o	24.70 klmn	26.20 L	463.0 op
	KCl	2.08 op	0.149 bcd	3.60 lmno	1.63 o	28.83 i	30.47 ghij	426.7 s
	Control	1.95 p	0.107 d	2.88 o	0.97 p	16.53 r	17.60 r	388.3 t

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

Table 9a: Effect of K-sources x EROC on yield and its components of broad bean during first seasons.

EROC	K sources	No. of pods / plant	Average Pod Weight (gm)	Yield / plant (gm)	Yield / plot (kg)	Seeds weight / pod (gm)	Pod length (cm)	Pod Diameter (cm)
		2000/2001 season						
	K_2SO_4	48.67 g	23.83 ef	1152.0 k	115.2 k	15.03 d	18.03 ef	21.00 abcd
	K_2CO_3	46.67 h	24.47 de	1141.0 L	114.1 n	15.00 d	22.03 a	20.67 abcd
	KH_2PO_4	40.00 j	23.80 ef	952.7 p	956.0 p	13.57 g	15.10 i	21.67 abc
ATP	KOH	51.00 f	25.67 b	1302.0 h	130.2 h	14.03 f	16.03 h	20.33 bcdef
	KNO_3	43.67 i	23.90 af	1048.0 o	104.8 o	14.47 e	17.03 g	1.97 cdef
	K-cit.	79.33 a	22.53 hijkl	1788.0 a	178.8 a	17.70 b	16.87 g	2.00 bcdef
	KCl	54.67 e	24.80 cd	1356.0 g	135.6 g	17.43 c	16.93 g	2.33 bcdef
	Control	37.33 k	21.47 mn	8017 k	801.7 t	11.00 L	15.90 h	2.00 bcdef
	K_2SO_4	48.00 gh	24.81 cd	1192.0 j	119.2 j	12.97 h	18.93 c	1.97 cdef
	K_2CO_3	54.67 e	24.70 cd	1351.0 g	195.1 g	17.27 c	15.90 h	1.80 efg
	KH_2PO_4	47.00 h	22.57 hijkl	1061.0 n	106.2 n	13.00 h	15.10 i	1.97 cdef
Citric acid	KOH	40.33 j	23.57 fg	951.0 p	95.13 p	12.93 h	17.87 f	2.00 bcdef
	KNO_3	46.67 h	22.77 hij	1063.0 n	107.3 n	13.03 h	17.03 g	1.56 g
	K-cit.	76.67 e	22.07 gklm	1696.0 b	169.6 b	18.07 a	16.70 g	2.30 a
	KCl	48.67 g	24.83 cd	1208.0 i	120.8 i	13.03 h	20.20 b	2.67 ab
	Control	34.67 m	22.13 ijklm	778.3 u	77.83 u	11.03 L	15.03 l	2.00 bcdef
	K_2SO_4	66.67 d	23.70 fg	1577.0 d	157.7 d	14.47 e	18.43 de	2.00 bcdef
	K_2CO_3	48.67 g	23.60 fg	1147.0 kl	114.7 kl	12.00 j	17.03 g	2.27 ab
	KH_2PO_4	51.00 f	25.43 bc	1297.0 h	129.7 h	12.07 j	17.00 g	2.27 ab
	KOH	55.00 e	26.33 a	1448.0 e	144.8 e	15.00 d	18.60 cd	2.16 abc
Glucose	KNO_3	47.67 gh	22.70 hijk	1082.0 m	108.2 m	12.00 j	16.03 h	1.83 def
	K-cit.	73.33 c	22.57 hijkl	1655.0 c	165.5 c	15.07 d	17.10 h	2.00 bcdef
	KCl	75.67 e	25.27 bc	1407.0 f	140.7 f	14.03 f	18.03 ef	1.87 def
	Control	34.33 m	21.90 lm	752.0 v	75.20 v	15.23 m	16.80 g	2.00 bcdef
	K_2SO_4	29.67 n	22.83 hi	678.0 w	67.80 w	8.50 o	18.02 ef	1.77 fg
	K_2CO_3	37.00 k	22.97 gh	848.7 s	84.87 s	10.00 n	18.00 ef	1.93 cdef
	KH_2PO_4	40.00 j	23.00 gh	920.0 p	92.00 q	11.47 k	18.00 ef	2.00 bcdef
Control	KOH	36.33 kl	22.00 klm	800.3 t	80.03 t	12.47 i	15.13 i	1.90 cdef
	KNO_3	39.00 j	23.20 fgh	904.7 r	90.47 r	13.47 g	17.10 g	2.00 bcdef
	K-cit.	40.00 j	23.70 fg	948.7 p	94.87 p	15.07 d	18.93 c	2.33 abcdef
	KCl	35.33 lm	21.20 n	750.0 v	75.00 v	10.00 n	16.93 g	1.87 def
	Control	27.00 o	20.40 o	552.0 x	55.20 x	8.07 p	15.80 h	1.93 cdef

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

Table 9b: Effect of K-sources x EROC on yield and its components of broad bean during second seasons.

EROC	K sources	No. of pods / plant	Average Pod Weight (gm)	Yield / plant (gm)	Yield / plot (kg)	Seeds weight / pod (gm)	Pod length (cm)	Po[illegible]d Diam[illegible]eter (cm[illegible])
		2001/2002 season						
ATP	K_2SO_4	49.67 g	33.77 efgh	1180.0 j	118.0 j	15.30 c	18.17 e	2.00 [illegible]cde
	K_2CO_3	47.33 h	24.67 bcde	1167.0 j	116.7 j	15.23 c	22.17 a	2.17 c[illegible]def
	KH_2PO_4	41.00 jk	23.97 def	983.3 m	98.33 m	13.72 g	15.20 h	2.30 [illegible]abc
	KOH	52.33 f	25.27 abcd	1322.0 h	132.2 h	14.33 f	16.17 g	2.17 c[illegible]def
	KNO_3	44.00 i	24.43 bcde	1075.0 L	107.7 L	14.73 d	17.23 f	2.10 c[illegible]efg
	K-cit.	81.00 a	22.50 ghijk	1829.0 a	182.2 a	18.30 a	17.13 f	2.10 c[illegible]efg
	KCl	55.67 e	24.50 bcde	1362.0 g	136.2 g	17.60 e	17.20 f	2.17 c[illegible]def
	Control	38.67 L	21.60 jk	826.3 q	82.63 q	11.27 L	16.13 g	2.00 f[illegible]ghi
Citric acid	K_2SO_4	48.00 gh	25.50 abc	1222.0 i	123.4 i	13.23 h	19.17 c	2.07 e[illegible]fgh
	K_2CO_3	56.33 e	24.07 cde	1370.0 g	137.0 g	17.53 b	16.03 g	1.90 hij
	KH_2PO_4	48.00 gh	22.67 fghijk	1088.0 L	108.8 kl	13.23 h	15.30 h	2.07 e[illegible]fgh
	KOH	41.00 j	23.73 efghi	980.0 m	98.0 mn	13.20 h	18.10 e	2.00 f[illegible]ghi
	KNO_3	48.67 gh	22.13 jk	1078.0 L	107.8 L	13.37 h	17.23 f	1.67 k
	K-cit.	77.33 b	22.43 ijk	1736.0 b	172.6 b	18.30 a	16.23 g	2.43 a.
	KCl	49.00 gh	24.93 abcde	1226.0 i	122.6 i	13.30 h	20.50 b	37 a[illegible]b
	Control	36.33 m	22.00 jk	800.0 r	80.0 r	11.30 L	15.23 h	2.00 e[illegible]fghi
Glucose	K_2SO_4	68.00 d	23.80 efg	1619.0 d	161.9 d	14.57 e	18.70 d	2.17 c def
	K_2CO_3	47.33 h	24.93 ebcde	1181.0 j	118.1 j	12.20 j	17.20 f	2.29 a[illegible]bcd
	KH_2PO_4	51.67 f	25.70 ab	1327.0 h	132.7 h	12.30 j	17.23 f	2.40 a
	KOH	56.33 e	26.03 a	1467.0 e	146.7 e	15.20 c	19.00 cd	2.20 b[illegible]cde
	KNO_3	49.00 gh	22.57 ghijk	1105.0 k	110.5 k	12.27 j	16.23 g	1.87 ij
	K-cit.	74.67 c	22.47 hijk	1678.0 c	167.8 c	15.20 c	16.17 g	2.07 e fgh
	KCl	56.00 e	25.27 abc	1418.0 f	141.8 f	14.27 f	18.23 e	1.93 g[illegible]hij
	Control	35.33 m	21.70 jk	7657.0 c	76.5 c	14.37 m	16.97 f	1.97 f[illegible]hij
Control	K_2SO_4	31.00 n	21.73 jk	681.0 t	68.10 t	8.67 o	18.20 e	2.07 e fgh
	K_2CO_3	38.67 L	22.43 ijk	860.3 p	86.07 p	10.17 n	18.13 e	2.03 e[illegible]fghi
	KH_2PO_4	40.67 jkL	22.90 fghij	931.7 o	93.17 o	11.63 k	18.27 e	2.00 e[illegible]ghi
	KOH	34.67 m	23.80 efg	825.0 q	82.50 q	12.70 i	15.13 h	1.80 jk
	KNO_3	39.00 kL	23.70 efghi	925.0 o	92.50 o	13.67 g	17.20 f	2.00 f[illegible]hi
	K-cit.	41.64 j	22.87 fghij	961.7 n	96.17 n	15.20 c	18.77 d	2.100 c[illegible]efg
	KCl	35.67 m	21.60 jk	771.0 s	77.10 c	10.27 mn	17.10 f	1.97 g[illegible]hij
	Control	27.33 o	21.43 k	585.0 u	58.50 u	8.30 p	15.90 g	2.03 e[illegible]ghi

Means having the same letter in the same column do not significantly differ using Duncan's Multiple Range Test.

VI. Correlation studies:

Data in Table (10) revealed that there was a positive correlation between number of pods / plant or weight of pod/plant from one hand and all the correlated traits from other hand at two seasons. The most pronounced ones were number of pods vs number of tillers, K, non-reducing and total sugars content. Also, pod average weight vs dry weight / plant, K, reducing and total sugars content. This ensuring the essentiality of K and sugars content for the best fruiting and yield of broad bean plants, and confirmed the tight relations between growth, chemical composition and yield of such crop. Also, emphasizing the essentiality of ambient K-supply and content for ameliorating of abscission problems and for increasing pod setting and maximizing broad bean yielding capacity.

Table 10: Correlations of pods number and weight vrs some traits during two seasons.

Characters	No. of pods / plant	
	2000/2001	2001/2002
No. of tillers	0.886	0.882
N (%)	0.742	0.715
P (%)	0.730	0.716
K (%)	0.800	0.730
Reducing sugars	0.484	0.448
Non-reducing sugars	0.813	0.823
Total sugars	0.839	0.850
	Pod average weight (gm)	
No. of tillers	0.324	0.238
N (%)	0.346	0.250
P (%)	0.270	0.218
K (%)	0.465	0.33
Reducing sugars	0.501	0.537
Non-reducing sugars	0.442	0.279
Total sugars	0.480	0.491

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إستجابة الفول الرومي للرش بمصادر بوتاسيوم مختلفة ومــواد طاقــة عضــوية لتحسين المحتوى الداخلي من البوتاسيوم والسكريات وزيــادة التفريــع والإثمــار والمحصول.

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أقيمت تجارب حقلية بالمزرعة البحثية بالمنصورة التابعة لمعهد البساتين خلال موســمي ٢٠٠٠ / ٢٠٠١ ، ٢٠٠١ / ٢٠٠٢ لدراسة تأثير الرش بمصادر بوتاسيوم مختلفة (سلفات ، كربونــات ، فوسـفات ، هيدروكسيد ، نترات ، سترات ، كلوريد بوتاسيوم) بتركيز واحد (١,٥ جم بو/لتر) والرش بمــواد عضــوية ذات صلة بتخليق الطاقة (أدينوزين تراى فوسفات ٥٠ جزء بالمليون ، حمض الستريك ٥ جم/لتــر وســكر الجلوكوز ١٠ جم/لتر) والتداخل بينهما على النمو والتركيب الكيماوي والمحصول للفــول الرومــي صــنف القبرصي بهدف تحسين المحتوى الداخلي من البوتاسيوم والسكريات لتحسين النمو وتقليــل مشــاكل تســاقط الأزهار والقرون الصغيرة وتعظيم الإنتاجية.

وكانت أهم النتائج كما يلي:-

١. تأثير المواد العضوية ذات الصلة بالطاقة: أعطت هذه المواد تأثيرات مفيدة بدرجة عاليــة وكانــت أفضلها الأدينوزين تراى فوسفات أو الجلوكوز والتي أدت إلى زيادة كبيرة في التفريع وتراكم المادة الجافة ومحتوى البوتاسيوم والسكريات ورافق ذلك زيادة كبيرة في عدد القرون والمحصول / نبــات والمحصول الكلي / وحدة المساحة.
٢. مصادر البوتاسيوم: كان لكل المصادر المستخدمة تأثيرات مفيدة معنوياً على التفريع وتراكم المــادة الجافة والمحتوى الداخلي مــن البوتاســيوم والسـكريات المختزلــة وغيــر المختزلــة والكليــة والكربوهيدرات الكلية وعدد القرون ووزن القرون والمحصول ، وكان المصدر العضوي للبوتاسيوم (سترات البوتاسيوم) هو أفضلها على الإطلاق.
٣. التفاعل (مصادر البوتاسيوم × مواد الطاقة): كانت أفضل المعــاملات هــي ســترات بوتاســيوم × أدينوزين تراى فوسفات ، سترات بوتاسيوم × الجلوكوز ، سترات بوتاسيوم × حمض الستريك.
٤. أظهرت نباتات الفول الرومي غير المعاملة حالة داخلية فقيرة في محتوى البوتاســيوم والســكريات إنعكست سلبياً على التفريع وعدد القرون ووزن القرون والمحصول بمعنى أن هذه النباتات عانــت بشدة من مشاكل تساقط الأزهار والقرون الصغيرة.
٥. كان هناك ارتباط إحصائي موجب وعالي بين محتوى السكريات غير المختزلة والكلية والبوتاســيوم مع عدد القرون ، كذلك السكريات المختزلة الكلية ومحتوى البوتاسيوم مع متوســط وزن القــرون وبين التفريع وعدد القرون.
٦. يمكن الإعتماد على محتوى الأوراق من الفوسفور والبوتاسيوم والسكريات الكلية كمؤشر جيد علــى الحالة الإنتاجية للنبات. الإنتاجية المنخفضة مرتبطــة بــالمحتوى (٠,١٠٣%، ٢,٨٦ % ، ١٧,٠ مجم/جم على التوالي) والإنتاجيــة المرتفعــة مرتبطــة بــالمحتوى (٠,٢٣٠% ، ٥,٧١% ، ٤٢,٧ مجم/جم على التوالي).

في النهاية نوصي برش سترات البوتاسيوم (٣٨% بو) (١,٥ جم بو / لتر) والأدينــوزين تــراى فوسفات (٥٠ جزء في المليون) لتحسين المحتوى الداخلي من البوتاسيوم والفوســفور والســكريات وزيــادة التفريع وتراكم المادة الجافة وزيادة عدد القرون وتعظيم المحصول لنباتات الفول الرومي.

كذلك تشير النتائج إلى أهمية تلك المعاملات كتقنية جديدة وبسيطة وسريعة وقليلة التكلفة لتعظــيم الإنتاجية والتغلب على الإنعكاسات السلبية لإجهادات التربة والمناخ.