J. Agric. Sci. Mansoura Univ., 27(5): 3439 - 3458, 2002

RESPONSE OF THREE BROCCOLI CULTIVARS TO DRIP IRRIGATION, MINERAL AND BIOFERTILIZATION TREATMENTS IN SANDY SOILS.

Hegazi, H.H.[1] and M. M. Attia [2]

[1]Department of Vegetable Crops, Faculty of Agric. El-Shatby, Alex. University.

[2]Soil, Water and Environment Res. Inst., ARC, Egypt.

ABSTRACT

Two field experiments were conducted at "Ali Mobarak" experimental research station, El-Bostan region, during 1999/2000 and 2000/2001 winter growing seasons, to determine the influence of water quantity, NPK rates and biofertilizer inoculations on the broccoli yield, quality and water utilization efficiency of some broccoli cultivars.

Results showed that there were significant differences between the 75% and 100% E_{pan} on plant vegetative growth characters, primary and secondary curds yield and its components, except those of secondary curds yield and NPK and vitamin C contents in different plant parts. Increasing water quantity was increased the most vegetative characters and primary curd diameter. Also, enhanced N contents in curds, stems and leaves and decreased plant dry weight percent, P, K and vitamin C in curds, stem and leaves of broccoli plant in both seasons.

Significant differences were obtained among Green Comet, Premium Crop and Pinnacle cultivars in all vegetative growth characteristics, primary and secondary curds yield and its components, N, P, K and vitamin C contents in different plant parts. Pinnacle cultivar, in general, recorded higher mean values in the most vegetative characters. While, Premium Crop cultivar gave significantly higher mean values of plant dry weight percent, primary and secondary average curd weight and total curds yield per feddan. Also, recorded higher means values of N,P, and K and vitamin C contents in curds, stems and leaves, except potassium contents in stem tissues.

Application the of half recommended doses of NPK used by broccoli growres through irrigation water gave higher values of vegetative growth, average primary curd weight, primary and secondary curd diameter, number of secondary curds per plant and total primary, secondary and total curds yield / feddan. And reflected significant and positive effects on N, P, K and vitamin C contents in different broccoli plant parts. While, the differences did not reach the significant level for phosphorus and potassium contents in the curds of broccoli plants.

Application of N_2-fixing bacteria mixture gave higher and significant increases for all studied characters in both seasons. N_2-fixing bacteria mixture increased average primary curd weight by 56.5 and 96.1 %, average secondary curd weight by 57.1 and 60.1, number of secondary curds by 40.6 and 42.4 primary curds yield by 56.6 and 60.8%, secondary curds yield by 122.4 and 129.1 and total curds yield per feddan by 82.6 and 85.7 compared with those of control in the tow growing seasons, respectively.

Interaction among water quantities, cultivars, NPK rates and biofertilizer treatments had significant effects on all vegetative growth characters, primary and secondary curds yield and its components, NPK and vitamin C in curds, stems and leaves of different broccoli parts in both growing seasons. The maximum mean values of plant fresh weight, primary and secondary broccoli curds yield and its components and N concentrations in curds, stems and leaves were recorded with Premium Crop cultivar under higher water quantity 100% E pan, recommended dose of NPK rate and N_2-fixing bacteria in both growing seasons.

The monthly amounts of irrigation water applied to broccoli plants varied from 58.8 to 516.6 m^3 / fed^{-1} in the first growing season and from 41.0 to 520.4 m^3 / fed^{-1} in the second growing season. The seasonal amounts of applied irrigation water were 1512.0 and 1134.0 m^3 / fed^{-1} for the 100 and 75 % Et_{pan} treatments in the first season, and were1667.0 and 1250.4 m^3 / fed^{-1} for the same previous treatments, in the second season.

Water utilization efficiency values ranged from 3.22 to 8.88 kg fresh curds yield /m^3 of irrigation water in the first season, and from 2.62 to 7.20 kg fresh curds yield /m^3 of irrigation water in the second season. The highest value of water utilization efficiency obtained by Premium Crop cultivar received 75% E pan, ½ NPK and inoculated with N_2–fixing bacteria.
Keywords: biofertelizer – *Brassica oleracea* L. spp. *Italica* - fertigation.

INTRODUCTION

Nubaria is a major production area for cool-season vegetables during the winter months. The average of broccoli and cauliflower produced in the desert has increased during the past 10 years. Vegetables produced in the sandy soil almost totally depend first on irrigation for their water requirement. Also, Nitrogen, phosphorus and potassium are the nutrient most limiting to crop production in this region. A high level of N fertility is generally a requirement for high broccoli yields (Cutcliffe *et al*., 1968).

In Egypt, chemical fertilizers are used heavily to maintain soil fertility and to ensure crop productivity. Badiane *et al.* (1994) reported that Egypt's consumption of fertilizers is 10 times more than the average for the whole world. Nitrogen fertilizer consumption was approximately doubled in 1993 as compared to 1980 (IFDC, 1993). High rates of chemical fertilizers being applied to different crops resulted in low N-recovery and low irrigation water efficiency, also, a significant amount of the applied N-fertilizer is lost (Hammisa *et al.*,1987; Abdel Monem *et al.,* 1994 and Soliman and Abdel Monem, 1994).

Drip irrigation system is a new practice of water application. Doorenbos and Pruitt (1984) indicated that class A pan method can be easily used for irrigation Scheduling of field crops. Fertilizer application through irrigation water (fertigation) is one of the latest and fastest new technologies in agriculture (Hairston *et al*., 1981 and Elfving, 1982) improving the efficiency of fertilizer recovery (Miller *et al.*,1982), minimizing losses due to leaching (Stark *et al.*,1983), optimizing the nutritional balance by supplying the nutrients directly to root zone and control of nutrient concentrations in the soil solution (Breslar, 1977).

Also, due to increasing international concern about environmental effect of N lost from fertilizer as leached nitrate or as volatile N gases, it is likely that there will be resurgence in the utilization of biofertilizers to compete or to replace fertilizer inputs (Peoples *et al.,* 1994). Biofertilizer are microbial inoculates used for application to seed or soil to increase soil fertility, with the objective of increasing the number of such microorganisms and to accelerate certain microbial processes in the rhizophere of inoculated plants. Such microbiological processes can change unavailable forms of nutrients into available forms that can be easily assimilated by plants (Alaa El-Din, 1982 and Subba Rao, 1981) by recycling elements, reserving natural resources from pollution due to the extensive use of mineral fertilizers. Also, they increase the amount of fixed nitrogen in the plants and amount of nitrogen left in the soil (Alaa El-Din, 1982).

A mixture of plant growth-promoting rhizobacteria (PGPR) consisting of N_2-fixing A*zotobacter*, *Azospirillum,* and *Klebsiella* was developed by Hassouna (1973 a and b) and registered as Halex. The application of such mixture proved to give significant higher growth values of sorghum fresh weight increases (38—50%) (Hassouna *et al*., 1991) and alfalfa increases by 29 -70% (Hassouna *et al.,* 1994).

Hassouna and Aboul-Nasr (1992) used Halex against soil-borne plant pathogens in soybeans. Abou-El Nasr *et al.* (1993) used N_2-fixing PGPR against *Fusarium* root rot, while Farfour (1995) used PGPR to control *Rhizoctonia* and *Schlrrochia*.

The objectives of the present study were to determine the influence of the following factors including a) water quantities, b) NPK rates and biofertilizer and; (c) water utilization efficiency on the broccoli yield and quality.

MATERIALS AND METHODS

Two field experiments were conducted at "Ali Mobarak" experimental research station, El-Bostan region, during 1999/2000 and 2000/2001 winter growing seasons, to study the effect of water quantity, NPK rates and biofertilizer on the broccoli yield and quality under surface drip irrigation system.

The surface drip irrigation system was inline drippers with a discharge of 4 liters/hour. Spacing between drip lines was 0.8m and between drippers was 0.5m. each drip line was attached to a tap that controls the opening and closing operations. The actual discharge was measured in the field along the drip line. Average discharge was 3.8 liters/hour due to pressure drop. Class A pan was used to schedule irrigation. Soil field capacity and wilting points for the experimental site were determined on mass basses by pressure extractor apparatus. Values of field capacity, wilting point, available soil moisture and bulk density determined for the soil of the experimental site are presented in Table 1.

The chemical and mechanical analysis of the experimental site are given in Table 2.

Table 1. Filed capacity (FC), wilting point (WP), available soil moisture (ASM) and bulk density (BD) values at the experimental site.

Soil Depth (cm)	Field Capacity (%)	Wilting point (%)	Available soil moisture (%)	Bulk Density g cm^3
0 – 15	11.2	5.3	5.9	1.46
15 – 30	10.9	5.1	5.8	1.66
30 – 45	9.5	4.6	4.9	1.71
45 – 60	9.2	4.2	5.0	1.83
Average	**10.2**	**4.8**	**5.4**	**1.66**

Table 2. Chemical and mechanical analysis of the experimental site.

Soil Depth (cm)	EC dSm^{-1}	pH	Soluble cations and anions meq/l						
			Ca	Mg	Na	K	HCO3	Cl	SO_4
0-30	0.38	9.16	1.25	0.60	1.60	0.20	1.18	1.80	0.75
30-60	0.32	9.22	1.10	0.55	1.44	0.15	1.02	1.60	0.63
Soil Depth (cm)	**Mechanical analysis**								
	Sand	**Silt**	**Clay**	**Texture class**					
0-30	90.9	3.6	5.5	Sandy					
30-60	91.5	2.8	5.7	Sandy					

Cattle manure at the rate of 20 m^3/fed was placed under the bed surface during the soil preparation. Twenty four equal doses of recommended and half-recommended amounts of mineral NPK were injected through drip irrigation system twice a week. Each dose contained 25 and 12.5 kg of ammonium sulfate 20% N, 4.8

and 2.4 kg of potassium sulfate 48% K_2O and 3.1 and 1.55 liter of phosphoric acid (85% P_2O_5) per feddan, respectively.

Preparation of N-fixers carrier:

Propagation of N-fixers, was carried out using 300 ml of sterilized N-deficient liquid media according to Jensen (1951) and Mac-Neil *et al.,* (1978) media, to grow A*zotobacter, Azospirillum* and *Klebsiella spp.* Cultures were kept at 26±1 ºC for two weeks. Bacterial films grown on the appropriate N-deficient liquid media were sieved, washed 3 times with sterilized double distilled water, and then mixed with talcum powder (as carrier) under aseptic conditions. After a thick paste was obtained, the mixture was allowed to dry at 28 ºC for 48 h, repowdered and kept in polyethylene bags in refrigerator till use.The number of N – fixing bacteria was estimated routinely every other week.

The statistical design was a split- split -split -plot experiment in randomized complete-block design with three replications. Main plots were two irrigation water quantities, i.e., 1-irrigation with amount of water equal to 75% of the evaporation from class A pan (75 % E_{pan}) 2- irrigation with amount of water equal to 100 % of the evaporation from class A pan (100% E_{pan}). Sub-plot treatments were three broccoli (*Brassica oleracea* L. spp. *Italica*) cultivars, i.e., Green Comet, Premium Crop and Pinnacle. The sub-sub-plot treatments were ½ NPK and NPK (recommended dose = 300 kg ammonium sulphate 20% N, 32 liter phosphoric acid (85% P2O5) and 50 kg potassium sulphate (48% K_2O) while, biofertilizer treatments, were 1- with bacterial mixture "Halex" and 2- without (control) These treatments were considered as sub-sub-sub-plot treatment. A mixture of plant growth-promoting rhizobacteria (PGPR) consisting of N_2-fixing A*zotobacter*, *Azospirillum*, and *Klebsiella* has been developed by Hassouna (1973 c) and registered as Halex. The three growth-promoting nitrogen rizobacteria (N_2-fixing PGPR), namely A*zospirillum barasilense* SBR, *Azotobacter chroococcum* ZCR, and *Klebsiella pneumoneae* KPR, with inocula densities 133 x 10^6, 166 x 10^5 and 10 x 10^7/ 50 ml, respectively, and chemically inert talcum powder, which served as a carrier, were chosen for this study. Each sub-sub-sub-plot consisted of three adjacent broccoli drip irrigation line 50 m long.

Drip irrigation tubing was placed in the bed center of all plots to supply water and fertilizer to the plants and for supplying water to specific main plot treatments. Seedlings of broccoli cultivars were transplanted on 17th and 20th Oct. 1999/2000, and 2000/2001 respectively, in 25 cm between plants in a line.Plants were evaluated for number of leaves, leaf area, and plant (aboveground) fresh and dry weight at curd initiation stage (about 50 days from transplanting. Curd, stem and leaf samples (most-recently matured leaf) were analyzed for N by a micro-Kjeldahl procedure, and for P, and K following dry ashing. Ascorbic acid (Vitamin c) content (mg/100g fresh weight of curd, stem and leaves tissues) was determined according to Groodzinsky and Groodzinsky (1973) These measurements were made so that we could determine the relative nutrient status and growth of plants receiving different amounts of water, NPK levels and biofertilizer treatments.

Mature broccoli curds were harvested after 75 and 73 days from transplanting. Secondary curds yield was extended from 5 Jan. to 10th of Feb. 2000 and from 1st Jan. to 5th Feb 2001.

Vegetative growth, primary, secondary and total curds yield and its components and chemical analysis data were statistically analyzed according to the design used by MSTAT-C software (1981). Treatment means (when F-test was significant) were compared using Revised LSD (Smith, 1978).

Water utilization efficiency values ($W.U_t.E$) of the irrigation treatments were calculated according to Jensen (1983) as follow:

$$W.U_t.E = \frac{\text{Marketable curds fresh yield (kg/m}^3\text{)}}{\text{Amounts of applied irrigation water (m}^3\text{/fed)}}$$

RESULTS AND DISCUSSION

I. Vegetative growth characteristics

Effect of water quantity:

Obtained data in Table 3 show that there were significant differences between the 75% E pan and 100% E pan on plant fresh weight in both growing seasons. Moreover, the number of leaves per plant, plant height and leaf area were increased with increasing the water quantity. But the increments did not reach the significant level. It could be suggested that increasing water quantity for broccoli plants led to keep higher moisture content in the soil, and this in turn favored and encouraged all plant metabolism. However, increasing water quantity showed insignificant decreases in plant dry weight percent in both seasons. These results agree with those reported by Hang and Miller (1986) and Marutani and Cruz (1989).

Effect of cultivar:

Data presented in Table 3 illustrate that there were significant differences among Green Comet, Premium Crop and Pinnacle cultivars in all vegetative growth characteristics in both growing seasons, except number of leaves / plant in both seasons. Pinnacle cultivar, in general, recorded higher mean values for number of leaves / plant, plant height and plant leaf area. While Premium Crop cultivar gave significantly higher mean values of plant fresh weight and plant dry weight percent. The variability among the studied broccoli cultivars might be due to the heredity differences and to variation in water and nutrient use efficiencies.

Effect of NPK rate:

Data in Table 3 show that application of the half recommended doses of N, P, and K used by broccoli grown on the newly reclaimed sandy soils gave higher number of leaves, plant height and leaf area per plant in the two growing seasons, except those of plant dry matter percent during the second season only. Also application of high NPK rate increased plant fresh weight significantly in the two seasons.

These results could be suggested that the application of drip irrigation method and addition of plant nutrients through irrigation water enhance the water and fertilizer use efficiencies, and enable plants to uptake the nutritional elements more efficient. Generally, fertilizer application through irrigation water (fertigation) improved fertilizer use efficiency (Hariston *et al.,* 1981 and Elfving, 1982)

Effect of biofertilizer:

It is obvious from data in Table 3 that addition of N_2-fixing bacteria “Halex” mixture, which consists of A*zotobacter*, *Azospirillum,* and *Klebsiella*, in general, gave higher and significant increases for plant growth characteristics. These results could be suggested that injection of N_2–fixing bacteria through irrigation water led to improvement the effects and increased the number of useful microorganisms in plant root zone. In addition, favorable effects could be produced due to N_2-fixing bacteria, which are: faster seed germination, gave better seedling emergence and increased plant growth (Kloepper *et al.,* 1989).

These results are in harmony with those reported by Choudhapy *et al.,* (1984) on peas plants and Hassouna *et al*., (1991 and 1994)on sorghum and alfalfa, respectively.

Effect of interaction among water quantiy, cultivar, NPK rate and biofetilizer:

It is clear from data in Table 3 that water quantity x cultivar x NPK rate x biofertilizer had significant effects on all vegetative growth characters in both growing seasons. The maximum mean values of plant fresh weight (940.3 and 867.3 g) were recorded with Premium Crop cultivar under higher water quantity 100% E pan, recommended dose of NPK rate and N_2-fixing bacteria in both growing seasons. However, Maximum plant height and leaf area were recorded, in general, with Pinnacle cultivar under higher water quantity, 100% E pan, recommended dose of NPK rate and N_2-fixing bacteria “Halex” mixture.

3

The obtained results could be explained in the light of variation of irrigation water quantity, the efficient utilization of NPK and biofertilizer through irrigation water on the side and the vital role of water and minerals and N_2-fixing bacteria on plant metabolism on the other side.

These results are in correspondence to those of El –Gamal, (1996) and Lazarovits and Nowak (1997), and more significant than those obtained by Sidorenko *et al.* (1996).

2- Primary, secondary and total curds yield and its components:

Effect of water quantity:

Data presented in Tables 4 and 5 show that increasing water quantity from 75 to 100 % Epan had favorable significant effects on the most primary and secondary curds yield and its components during both seasons, except those of secondary curds yield. Moreover, increasing the water quantity increased primary curd diameter but the increment did not reach the significance level.

The noticed increments in primary yield and its components may be due to increases in plant growth characters occurred under higher irrigation water quantity (Table 3). While, increases in secondary curds yield may be due to the direct effect of water on the initiation of more lateral buds. These results agree with those obtained by Gawish (1992) who reported that the detrimental effect of water stress on yield might be due to reduction in vegetative growth. Moreover, low soil moisture potential, adversely, affected hormonal balance, plant development, translocation and portion of assimilates of photosynthesis among different organs which in turn resulted in low average curd weight, diameter and curds yield.

Effect of cultivar:

Data in Table 4 show that there were significant differences among Green Comet, Premium Crop and Pinnacle cultivars on primary and secondary curds yield and its components (Tables 4 and 5) in both growing seasons. Premium Crop cultivar gave higher mean values of primary and secondary average curd weight and total curds yield per feddan compared with those of Green Comet and Pinnacle cultivars. On the other side, Pinnacle cultivar was recorded the highest mean values for primary and secondary curd diameter and number of curds per plant. The differences among cultivars could be due to differences in heritable genes. These results agree with those reported by Batal, (1977) in cauliflower.

Effect of NPK rate:

It is clear from data presented in Table 4 that addition of the half recommended dose of NPK had significant effects on average primary curd weight, primary and secondary curd diameter, number of secondary curds per plant and total primary, secondary and total curds yield / feddan in both growing seasons (Tables 4 and 5).

These results may be due to the stimulation effects of the recommended dose of NPK on the broccoli vegetative growth characters in Table 3 and in the light of using the most efficient irrigation system (drip irrigation) and applying minerals through irrigation water (fertigation) where, fertilizer application through irrigation water is one of the latest and fastest new technologies in agriculture (Hairston *et al*., 1981 and Elfving, 1982). This method could be help in improving the efficiency of

fertilizer recovery (Miller *et al.*,1982), minimizing losses due to leaching (Stark *et al.*,1983), optimizing
the nutritional balance by supplying the nutrients directly to root zone and control of nutrient concentrations in the soil solution (Breslar, 1977).

Table 5: Primary, secondary and total broccoli curds yield as influenced by the main and interaction effects of irrigation water quantities, cultivars, NPK rates and biofertilizer treatments during the seasons of 1999 and 2000.

Treatment				Primary curds yield	Secondary curds yield	Total yield	Primary curds yield	Secondary curds yield	Total yield
				Ton/ feddan					
				1999/2000			2000/2001		
75 % Epan				3.86 B	3.38 A	7.25 B	3.65 B	2.94 A	6.59 A
100 % Epan				4.34 A	3.23 B	7.57 A	4.07 A	2.72 B	6.79 A
	Green Comet			3.967C	3.12 B	7.08 C	3.721C	2.750A	6.47 B
	Premium Crop			4.269A	3.40 A	7.68 A	4.025A	2.867A	6.90 A
	Pinnacle			4.069B	3.70 A	7.46 B	3.828B	2.875A	6.70 A
		½NPK		4.17 A	3.34 A	7.51 A	3.92 A	2.88 A	6.80 A
		NPK		4.03 B	3.27 A	7.31 B	3.79 B	2.78 A	6.58 B
			Cont	3.20 B	2.05 B	5.24 B	2.96 B	1.72 B	4.68 B
			Halex	5.01 A	4.56 A	9.57 A	4.76 A	3.94 A	8.69 A
75 % Epan	Green Comet	½ NPK	Cont	2.706 m	1.667 i	4.33 l	2.449 g	1.667 h-k	4.10 kl
			Halex	4.855 de	4.367 cde	9.23 ef	4.803 bc	4.200 ab	9.00 b
		NPK	Cont	2.728 lm	1.700 i	4.47 kl	2.471 g	1.533 jk	4.00 l
			Halex	4.693 ef	4.767 ab	9.47 def	4.528 cd	4.267 a	8.77 bcd
	Premium Crop	½ NPK	Cont	3.080 jk	2.367 f	5.43 i	2.911 f	1.933 f-i	4.87 hi
			Halex	5.078bcd	4.967 a	10.07 b	4.690 c	4.267 a	8.93 bc
		NPK	Cont	3.043 jk	2.033 gh	5.10 ij	2.842 f	1.600 ijk	4.43 jk
			Halex	4.928cde	4.633 bcd	9.60 cde	4.653 c	3.900bcd	8.57cde
	Pinnacle	½ NPK	Cont	3.032 jk	2.400 f	5.43 i	2.801 f	2.067 fg	4.87 hi
			Halex	4.734 ef	4.667abc	9.40 def	4.580 cd	3.900bcd	8.43 def
		NPK	Cont	2.963 kl	2.433 f	5.37 i	2.801 f	1.967 fgh	4.77 ij
			Halex	4.525 f	4.533 bcd	9.07 f	4.272 d	4.033abc	8.30 ef
100% Epan	Green Comet	½ NPK	Cont	3.267 ij	1.833 hi	5.13 ij	2.970 f	1.367 k	4.37 jkl
			Halex	5.236 b	4.500 bcd	9.70 bcd	5.038 ab	3.567 de	8.60b-e
		NPK	Cont	3.186 jk	1.700 i	4.87 jk	2.717 fg	1.400 jk	4.13 kl
			Halex	5.067bcd	4.400 cde	9.47 def	4.789 bc	4.000abc	8.80bcd
	Premium Crop	½ NPK	Cont	3.450 hi	2.033 gh	5.50 hi	3.388 e	1.633 h-k	5.03 hi
			Halex	5.746 a	4.800 ab	10.5 a	5.302 a	4.233 ab	9.53 a
		NPK	Cont	3.527 gh	1.800 hi	5.33 i	3.315 e	1.567 jk	4.87 hi
			Halex	5.302 b	4.600 bcd	9.90 bc	5.097ab	3.800cde	8.93 bc
	Pinnacle	½ NPK	Cont	3.703 g	2.367 f	6.07 g	3.329 e	2.167 f	5.50 g
			Halex	5.137 bc	4.167 e	9.30 def	4.822 bc	3.533 e	8.33 ef
		NPK	Cont	3.689 gh	2.267 fg	5.90 gh	3.498 e	1.733 g-j	5.27 gh
			Halex	4.767 e	4.333 de	9.13 f	4.517 cd	3.600 de	8.13 f

***Values marked with the same letter (s) are statistically similar using LSD test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**

Effect of biofertilizer:

It is evident from data in Tables 4 and 5 that application of N_2-fixing bacteria mixture had significant effect on primary and secondary broccoli yield and its components in both seasons. N_2-fixing bacteria mixture (A*zotobacter, Azospirillum,* and *Klebsiella)* increased average primary curd weight by 56.5 and 96.1 %, average secondary curd weight by 57.1 and 60.1, number of secondary curds by 40.6 and 42.4 primary curds yield by 56.6 and 60.8%, secondary curds yield by 122.4 and 129.1 and total curds yield per feddan by 82.6 and 85.7 compared with those of control in the tow growing seasons, respectively. The simulative effects of N_2-fixing bacteria mixture may due to their favourable effects on increasing soil fertility and accelerate certain microbial processes in the rhizophere of inoculated plants. Such microbiological processes can change unavailable forms of nutrients into available forms that can be easily assimilated by plants (Alaa El-Din, 1982 and Subba Rao, 1981). Also, recycling elements and increasing the amount of fixed nitrogen in the plants and amount of nitrogen left in the soil (Alaa El-Din, 1982)

On the other hand, N_2-fixing bacteria used successfully and gave significant higher growth values of sorghum fresh weight Hassouna *et al*. (1991) and increased alfalfa fresh weight by 29 -70% Hassouna *et al.* (1994). Inoculation orarious crops with A*zotobacter* and/or *Azotobacter* or Halex increased growth of treated plants Hassouna and Wareing, (1964) and Hassouna, (1973a, 1973b). Also, Hassouna and Aboul-Nasr (1992a) used Halex against soil-borne plant pathogens in soybeans. Aboul Nasr *et al.* (1993) used N_2-fixing PGPR against *Fusarium* root rot, while Farfour (1995) used PGPR to control *Rhizoctonia* and *Schlrrochia*.

These results are in harmony with those obtained by El-Gamal, (1996).

Effect of interaction among water quantiy, cultivar, NPK rate and biofetilizer:

Data presented in Tables 4 and 5 showed that interactions among water quantity, cultivar, NPK rate and biofertilizer gave significant effects on all primary and secondary curds yield and its components.

The highest mean values of broccoli yield and its components were obtained, in general, with Premium Crop cultivar received 100% E pan, half recommended NPK dose and N_2-fixing bacteria; Halex mixture. However, maximum mean values of secondary curd weight (47.00 and 43.37) were obtained with Premium Crop cultivar received higher dose of NPK. Also, Pinnacle cultivar receive low water quantity (75 % E pan), half recommended NPK dose and N_2-fixing bacteria gave higher number of secondary curds per plant (5.70 and 5.03) Table (4) in the two seasons, respectively.

The different interaction effects of broccoli cultivars received different water quantities, NPK doses and biofertilizer treatments are quite expected due to varietal variations. Obtained results may be explained also on the base that increased moisture content, adequate amounts of NPK and biofertilizer application through irrigation water produced higher plant growth and yields.

3- Plant chemical composition

Effect of water quantity:

Data presented in Tables 5 and 6 show that there were significant differences between water quantities in all studied chemical constituents. Increasing irrigation water quantity enhanced N contents in curd, stem and leaves. While, increasing of water quantity, in general, decreased P, K and vitamin C in different broccoli plant parts.

The noticed increases of N contents in different broccoli plant parts under higher irrigation water quantity may due to the increments in available water in soil, factor that affected positively nitrogen uptake and accumulation in plant tissues.

These results are in correspondence with those of Abou-El-Magd (1979) on garlic and Abd-alla (1992) on onion plants. The increase in dry matter content under low water quantity may account for the higher P and K contents in curds, stems and leaves.

Effect of cultivar:

Data illustrated in Table 5 and 6 show that there were significant differences among studied cultivars for N, P, K and vitamin C contents in different broccoli plant parts. Generally, Premium Crop cultivar recorded higher means values of NPK and vitamin C contents in curds, stems and leaves, except potassium contents in stem tissues in the two growing seasons. These results may due to the differences among cultivars used.

Effect of NPK rate:

It is obvious from data in Table 5 and 6 that increasing NPK fertilizer rate up to the recommended dose reflected significant and positive effects on N contents in curd, stem and leaves. Meanwhile, using a half of the recommended dose through irrigation water (fertigation) gave, significantly, higher P, K and vitamin C contents in different broccoli plant parts. While, the differences did not reach the significant level for phosphorus and potassium contents in the curds of broccoli plants in the second growing season. These results could be explained in the light of variations in accumulation of higher dry matter on one side and using efficient amounts of NPK nutrient through irrigation water on the other side.

Effect of biofertilizer:

Data presented in Table 5 and 6 illustrate that NPK and vitamin C contents of curd, stem and leaves were significantly increased with application of N_2-fixing bacteria mixture “Halex” in both seasons.

It could be suggested that addition of N_2-fixing bacteria suspension through irrigation water increased soil fertility and eliminated soil-born pathogens and Fusarium root rot (Abou-El Nasr *et al.*, 1993) and control *Rhizoctonia schrolilus.* Also, biofertilizer inoculates change unavailable forms of nutrients into available forms that can be easily assimilated by plant (Alaa El-Din, 1982 and Subba Roa, 1981).

Effect of interaction among water quantity, cultivar, NPK rate and biofetilizer:

It is obvious from data presented in Tables 5 and 6 that the interaction of water quantity x cultivar x NPK rate and biofertilizer inoculation had significant effects on concentrations of NPK and vitamin C in curd, stem and leaves of broccoli plants.

In general, the highest mean values of N concentrations in curd, stem and leaves were obtained with “Premium Crop” cultivar received 100% Epan, higher NPK rate and inoculated with N_2-fixing bacteria, in both seasons. While higher K and vitamin C concentrations were obtained with the same cultivar received 75 % Epan, half NPK rate and inoculated with N_2-fixing bacteria. Moreover, Phosphorus concentrations in curd, stem and leaves had no significant trend.

Obtained results may explained on the base that “Premium Crop” cultivar reacted more with higher water quantity applied, higher NPK rate and biofertilizer treatments more than those of “Green Comet” and “Pinnacle” cultivars and formed higher vegetative growth, dry matter and produced higher yield.

These results supported the findings of Mahendran *et al.* 1996, who found that split application of 100% of the recommended dose of the NPK with biofertilizers

Azospirillium and *Phosphobacterium* significantly influenced the N and P and dry matter contents by different plant parts.

4-Amounts of applied irrigation water

Amount of applied irrigation water to the broccoli plants for the two growing seasons are presented in Table 8. Results indicated that the monthly amounts of irrigation water applied to broccoli plants varied from 58.8 to 516.6 m^3 / fed^{-1} in the first growing season and from 41.0 to 520.4 m^3 / fed^{-1} in the second growing season. The maximum values of applied irrigation water occurred in November in the first and second seasons. The seasonal amount of applied irrigation water were 1512.0 and 1134.0 m^3 / fed^{-1} for the 100 and 75 % Et pan treatments in the first season, while in the second season were 1667.0 and 1250.4 m^3 / fed^{-1} for the same previous treatments, respectively.

5- Water utilization efficiency (W.Ut.E.)

Water utilization efficiency values are used to evaluate the effectiveness of irrigation treatments on maximizing water utilization by broccoli crop. The results in Table 9 showed that W.Ut.E. values ranged between 3.22 to 8.88 kg broccoli fresh curds yield per cubic meter of irrigation water in the first season, while, in the second season ranged between 2.62 to 7.20 kg fresh curds yield per cubic meter of irrigation water. The highest value of water utilization efficiency obtained by Premium Crop cultivar received 75% E pan, ½ NPK and inoculated with N_2 – fixing bacteria in the first growing season. However, in the second growing season, the highest value obtained by Green Comet cultivar received 75 % E pan, ½ NPK and treatment with N_2- fixing bacteria. The obtained W.Ut.E. values were in the range reported by Farrag *et al*. (2000). They mentioned that water use efficiency values for cauliflower crop under drip irrigation system are in the range of 4.421 to 5.838 kg / m^3 in the second growing season.

Table 8. Amounts of applied irrigation water (m^3/ fed^{-1}) for broccoli crop as affected by irrigation water treatments during 1999/2000 and 2000/2001 winter seasons.

Season	1999/2000		2000/2001	
Month	Irrigation treatments			
	75 % Epan	100% Epan	75 % Epan	100% Epan
Oct.	193.2	256.2	374.5	499.3
Nov.	386.4	516.6	390.3	520.4
Dec.	310.8	415.8	246.1	328.1
Jan.	184.8	243.6	198.5	264.6
Feb.	58.8	79.8	41.0	54.6
Total	1134.0	1512.0	1250.4	1667.0

Table 9: Water utilization efficiency (W.Ut.E.) for broccoli crop as influenced by the main and interaction effects of irrigation water quantities, cultivars, NPK rates and biofertilizer treatments during the seasons of 1999 and 2000.

Treatment		1999/2000		2000/2001	
		W. Ut.E. (Kg fresh curds / m^3 water)			
		75 % Epan	100% Epan	75 % Epan	100% Epan
Water quantity		6.39	5.01	5.27	4.08
	Green Comet	6.06	4.82	5.17	3.89
	Premium Crop	6.66	5.17	5.36	4.26
	Pinnacle	6.45	5.03	5.27	4.09

	½NPK		6.45	5.10	5.36	4.14
	NPK		6.33	4.92	5.18	4.01
		Cont	4.43	3.62	3.60	2.92
		Halex	8.36	6.40	6.93	5.23
Green Comet	½NPK	Cont	3.82	3.39	3.28	2.62
		Halex	8.14	6.42	7.20	5.16
	NPK	Cont	3.94	3.22	3.20	2.48
		Halex	8.35	6.26	7.01	5.28
Premium Crop	½NPK	Cont	4.79	3.64	3.89	3.02
		Halex	8.88	6.96	7.14	5.72
	NPK	Cont	4.50	3.53	3.55	2.92
		Halex	8.47	6.55	6.85	5.36
Pinnacle	½NPK	Cont	4.79	4.01	3.89	3.30
		Halex	8.29	6.15	6.74	5.00
	NPK	Cont	4.73	3.90	3.81	3.16
		Halex	8.00	6.04	6.64	4.88

REFFERENCES

Abd Alla, A.A. (1992). Effect of soil moisture stress and nitrogen fertilization on onion plant. Ph.D. Thesis, Fac. Agric., Ain Shams Univ., Cairo (A.R.E).

Abdel Monem, M.; M. Abdel Khaiek and M. Abdel-Ghani. (1994). Fertilizer abuse as a possible threat to water quality in Egypt. Proceedings of the VIII IWRA World Congress on Water Resources, 21-25 November 1994, Egypt.

Abou El-Magd, M.M. (1979). Effect of level of soil moisture and nitrogen fertilizer on the growth, nitrogen metabolism and yield of garlic. Ph.D. Thesis, Fac. Agric., Zagazig Univ., Zagazig (A.R.E).

Abou El-Nasr, A.; A. Y. El-.Sharkawy and M. G. Hassouna. (1993). Effect of endomycorrhiza and N_2-fixing rhizobacteria on plant growth and development of Fusarium root rot of cucumber in calcareous soil. J of Agric. Sci. Mansoura Univ., 18:1793-1774.

Alaa El-Din, M. N. (1982). Biofertilizers-requirements and application. FOA Soils Bulletin, 45: 164-174.

Badiane, 0.; M. Bader; M.R El-Amir; A. EI-Miniawy; F. Goletti and J. Soil (1994). Agriculture Input and Output Market Reform in Egypt. Initial Impact and Future Policy Issues. Paper 113-Report Submitted to MALR, Egypt and the International Food Policy Research Institute, Washington, D.C.

Batal, K.M.; D.M.Granberry and Jr Mullinix (1997). Nitrogen, magnesium and boron application affect cauliflower yield, curd mass, and hollow stem disorder. Hort. Sci., 32(1):75-78.

Breslar, E. (1977). Trickle-drip irrigation: Principles and application to soil-water management. Adv. Agron., 29 : 343-393.

Bucks, D.A. and S. Davis. 1986. Trickle Irrigation for Crop Production. Chapter1, Eds.F.S. Nakayama and D.A. Bucks. Netherlands. Elsevler Publications.

Choudhapy, U.; C. B.Rajpul and H. Ram (1984). Effect of *Azotobacter* and *Rhizobium* treatment on growth, yield and quality of peas (*Pisum sativum* L.) Haryana J. Hort. Sci., 11: 231-234.

Cutcliffe, J.A.; D.C. Munro and D.C. MacKay (1968). Effect of nitrogen, phosphorus, potassium, and manure on terminal, lateral, and total yields and maturity of broccoli. Can. J. Plant Sci., 48(5):439-446.

Doorenbos, J. and W. O. Pruitt. (1984). Crop water requirements, Irrigation and Driange. Paper No. 24, FAO, Rome. Italy.

El- Gamal, A.M. (1996). Response of potato in the newly reclaimed area to mineral nitrogen fertilizer levels and nitrogen fixing biofertilizer HALEX2. Assiut J. Agric. Sci., 27(2):89-99.

Elfving, D.C. (1982). Crop response to trickle irrigation. Hort. Rev. 4 : 1 – 48.

Farour, S.A. (1995). Agricultural production of protected plants by applying plant growth-promoting rhizosphere microorganisms. MSc. Thesis in Plant Pathology, Fac. Agric. Alex. Univ. Alex. Egypt.

Farrag, A. M.; J. F. Mishriky and A.M. El-Nagar (2000). Effect of drip irrigation levels and nitrogen rates on growth and yield of cauliflower plants and salt accumulation in soil. J. Agric. Sci. Mansoura Univ., 25 (5):2855-2875.

Gawish, R.A. (1992). Effect of antitranspirants application on snap beans (*Phaseolus vulgaris* L.) grown under different irrigation regimes 1-Growth, transpiration rate and leaf content of water, NPK and total carbohydrates. Menofiya J. Agric. Res., 17: 1285-1308.

Grodzyinsky, A.M. and D. M. Grodzinsky (1973). Short reference in plant physiology Naukova Domka Riev. R.U.R. 433-434.

Hairston, J.E.; I.S. Schepers and W. L. Colville (1981). A trickle irrigation system for frequent application of nitrogen to experimental plots. Soil. Sci. Am J., 45: 880-882.

Hammissa, M.R.; M.S. Khadr; M.H. Taha; Y.H. Mohamed and M.I. El-Mallah (1987). Symbiotic nitrogen fixation by some legume crops as affected by different levels of fertilizer N using ^{15}N. 1st Conf. of Fertilization, 2-7 April 1987, Cairo, Egypt.

Hang, A.N. and D.E. Miller (1986). Yield and physiological responses of potatoes to deficit high frequency sprinkler irrigation. Agron. J., 78: 436-440.

Hassouna, M.G. (1973a). Biological curing of nitrogen deficiency in Gramineae. I. Inoculation of barley grown in pots with non-symbiotic N_2-fixers. Proceedings of the First Congress of the Egyptian Phytopathological Society, Nov. 12-15, 1973. Cairo, Egypt. Academy of Scientific Research and Technology.

Hassouna, M. G. (1973b). Biological curing of nitrogen deficiency in Gramineae. II. Inoculation of arley grown under field conditions with non-symbiotic N_2-fixers. Proceedings of the First Congress of the Egyptian Phytopathological Society,

Nov. 12-15, 1973. Cairo, Egypt. Academy of Scientific Research and Technology

Hassouna, M. G.; I. A. Ibrahim and M. A. Madkour (1973). Biological curing of nitrogen deficiency in Gramineae. III. Nitrogen content of wheat plants inoculated with non-symbiolic N-fixers. Proceedings of the First Congress of the Egyptian Phytopathological Society, Nov. 12-15, 1973. Cairo, Egypt. Academy of Scientific Research and Technology.

Hassouna, M. G.; M. A. Madkour and T. Mahmoud (1991). Growth promotion of sorghum by asymbiotic N_2-fixers in Egyptian poor lands of the N.W. coast, pp. 68-72, in C. Keel, B. Koller, and G. Defago, Eds.. Plant Growth-Promoting Rhizobacteria: Progress and Prospects. The Second International Workshop on Plant Growth Promoting Rhizobacteria, International Union of Biological Sciences, Interlaken. Switzerland.

Hassouna, M. G. and A. Aboul-Nasr. (1992). Application of growth promoting rhizobacteria and vesicular arbuscular mycorrhiza on soybean (*GIycine max*) on the poor lands of N.W. Egypt, Communications in Science and Development Research, 39:47-61.

Hassouna, M. G.; M. Th. Hassan and M. A. Madkour (1994). Increased yields of alfalfa (*Medicago sativa*) inoculated with N_2-fixing bacteria and cultivated in a calcareous soil of northwestern Egypt. Arid Soil Research and Rehabilitation, 8: 389-393.

Hassouna, M.G.; M. A. El-Saedy and H.M.A Saleh (1998). Biocontrol of soil-borne plant pathogen attacking cucumber (*Cucumis sativus* L.) by rhizobacteria in a semiarid environment. Arid Soil Res. Rehab., 12: 345-357.

Hassouna. M. G. and P. F. Wareing (1964). Possible role of rhizosphere bacteria in the N-nutrition of Ammophila arenaria. Nature, 202:467-469. International Fertilizer Development Center. (1993). Fertilizer Policy Impact Study. IFDC, Muscle Shoal, Alabama, USA.

Jensen, H. L. (1951). Notes on the Biology of Azotobacter. Proceedings of the Society of Applied Bacteriology, 14:89-94.

Jensen, M.E. (1983). Design and operation of farm irrigation systems. Amer. Soc. Agric. Eng. Michigan. USA. p. 827.

Kloepper, J.W.; R. Lifshitz and R.M. Zablotowicz (1989). Free-living bacterial inocula for enhancing crop productivity. T.I.B. Tech., 7: 39-44.

Lazarovits, G and J. Nowak. (1997). Rhizobacteria for improvement of plant growth and establishment. Hort.Sci., 32(2): 188-192.

Mac Neil, T. ; W.J. Brill and M.M. Howe (1978). Bacteriophage Mu-induced deletions in a plasmid containing the nif (N_2 fixation) genes of *Klebsiella pneumoniae*. J. Bact., 134: 821.

Mahendran-PP; Kumar-M; S. Saraswathy (1996). Studies on the effect of biofertilizers on potato (*Solanum tuberosum* L.). South Indian Hortic., 44 (3-4): 79-82.

Marutani. M. and F. Cruz (1989). Influence of supplemental irrigation on development of potatoes in the tropics. Hort.Science, 24(6): 920-923

Miller, R.J.; D.E. Rolston; R.S. Raushkolb and D. W. Wolfe (1982). Labeled nitrogen uptake by drip irrigated tomatoes. Agron. J., 73: 265-270.

MSTAT-C software.(1981). Russel. D.F., Crop and Soil Sciences Department Michigan State University. Version 1.2.

Peoples, M.B.; D.F. Herridge and J.K. Ladha (1994). Biological nitrogen fixation: an efficient source of nitrogen for sustainable agriculture production. 15th World Congress of Soil Science. July, Acapulco, Mexico.

Phene, C. J. and R.C. .Phene (1987). Drip irrigation systems and management. Food and Fertilizer Technology Center. Ext. Bull. 244, Taipei, Taiwan.

Sidorenko,O.; V.Storozhenko and O. Kukharenkova (1996).The use of bacterial preparations in potato cultivation. Mezhdunarodnyi Sel'skokhozyaistvennyi Zhurnal. 1996, No. 6, 36-38 (c. a. International network).

Smith, C. W. (1978). Bayes least significant difference. A review and comparison. Agron. J., 70:123-127.

Soilman, S. and M. Abdel Monem (1994). Influence of ^{15}N labeled urea and Azotobacter on corn yield and nitrogen budget as affected by organic matter. Proceedings of the 2nd Arab Conference on the Peaceful Uses of Atomic Energy. 5-9 Nov.1994. Cairo, Egypt.

Stark, J.C.; W.M. Jarrell; J. Letey and N. Valoras (1983). Nitrogen use efficiency of trickle-irrigated tomatoes receiving continuous injection of N. Agrorn. J., 75: 672-676.

Subba Rao, N. S. (1981). Biofertilizers in Agriculture. Oxford and IBH Publishing Co., New Delhi, Bombay, Calcutta. pp. 212-225.

استجابة ثلاث أصناف من البروكولي لمعاملات الري بالتنقيط والتسميد المعدني والحيوي في الأراضي الرملية

[١]حجازي حسن حجازي و [٢]محمود محمد عطيه
[١] قسم الخضر - كلية الزراعة – جامعة الإسكندرية
[٢]قسم المقننات المائية والري الحقلي – معهد بحوث الأراضي والمياه – الجيزة

أجريت تجربتان حقليتان في شتاء موسمي ١٩٩٩/٢٠٠٠ و ٢٠٠٠/٢٠٠١ بمزرعة بحوث البساتين – جنوب التحرير – البستان – منطقة النوبارية، بهدف دراسة تأثير كميات مياه الري والأصناف و مستويات التسميد المعدني و الحيوي على جودة ومحصول ومحتوي النبات من NPK وفيتامين ج تحت ظروف الأراضي الرملية باستخدام نظام الري بالتنقيط. تضمنت الدراسة ٢٤ معاملة. أشارت النتائج المتحصل عليها إلى:

أثرت معدلات مياه الري المستخدمة معنوياً في على صفات النمو الخضري والمحصول الأولي والثانوي ومكوناته ماعدا صفة محصول الأقراص الثانوية ومحتوى الأقراص والسيقان والأوراق من NPK وفيتامين ج. زادت صفات النباتات الخضرية وقطر القرص الزهري ومحتوى الأقراص والسيقان والأوراق من النتروجين بزيادة كمية المياه المستخدمة. بينما أدت زيادة كميات المياه إلى انخفاض النسبة المئوية للمادة الجافة ومحتوي أجزاء النبات المختلفة P,K وفيتامين ج خلال موسمي الزراعة.

اختلفت الأصناف المستخدمة فيما بينها معنوياً في جميع الصفات المدروسة. وتفوق الصنف Pinnacle معنوياً على باقي الأصناف في جميع الصفات الخضرية. بينما، تفوق الصنف Premium Crop معنوياً في الصفات المحصولية ومحتوى أجزاء النبات المختلفة من NPK وفيتامين ج. وأدي استخدام نصف كمية السماد المعدني الموصى بها عند الزراعة في الأراضي الرملية مع مياه الري في الحصول على زيادة معنوية في جميع الصفات الخضرية والمحصولية والمحتوي الكيماوي وفيتامين ج في أجزاء النبات المختلفة. كما أثبتت النتائج أن أستخدام الأسمدة الحيوية مع مياه الري أعطى زيادة معنوية في جميع الصفات الخضرية والمحصولية ومحتوى الأقراص والسيقان والأوراق من عناصر NPK وفيتامين ج بالمقارنة بالكنترول (بدون معاملة).

كما أثرت التفاعلات بين معدلات الري والأصناف ومعدلات التسميد المعدني والحيوي تأثيراً معنوياً على جميع الصفات المدروسة. وأعطى التفاعل بين الصنف Premium Crop تحت المعدل لأعلى من مياه الري (١٠٠% نتح – بخر قياسي) ونصف كمية السماد المعدني الموصى بها والتسميد بالبكتريا المثبتة للنتروجين أكبر نمو خضري ومحصول أقراص أولي وثانوي ومكوناته و أكبر محتوي من NPK وفيتامين ج في كل من الأقراص والسيقان والأوراق لنبات البروكولي.

اختلفت كميات المياه المضافة شهرياً لنباتات البروكولي من ٥٨,٨ إلى ٥١٦,٦ م^{٣} في موسم النمو الأول ومن ٤١,٠ إلى ٥٢٠ م^{٣} في موسم النمو الثاني، كما اختلفت كميات المياه المضافة للفدان من ١١٣٤,٠ إلى ١٥٢٠,٠ م^{٣} في موسم النمو الأول ومن ١٢٥٠,٤ إلى ١٦٦٧,٠ م^{٣} في موسم النمو الثاني لمعدلات ٧٥ و ١٠٠% من معدل البخر- نتح القياسي، على التوالي. وتراوحت كفاءة استعمال المياه من ٣,٢٢ إلى ٨,٨٨ كم أقراص بروكولي طازجة/ م^{٣} مياه في موسم النمو الأول ومن ٢,٦٢ إلى ٧,٢٠ كم أقراص بروكولي طازجة/ م^{٣} مياه في موسم النمو الثني. وأعطي التفاعل بين الصنف Premium Crop و معدل الري الأعلى ١٠٠% بخر – نتح القياسي ونصف كمية السماد المعدني و التسميد الحيوي أعلى كفاءة لاستعمال مياه الري.

Table 3. Broccoli vegetative growth characteristics as influenced by irrigation treatments, cultivars, NPK levels and biofertilizer during 1999 and 2000.

Treatments			Plant fresh weight (g)	Leaves no.	Plant height (cm)	Leaf area (cm^2)	Plant dry matter %	Plant fresh weight (g)	Leaves no.	Plant height (cm)	Leaf area (cm^2)	Plant dry mattert %
			1999/2000					**2000/2001**				
75 % E_{pan}			**626.53 B**	**17.25 A**	**53.34 A**	**628.81 A**	**11.83 A**	**603.06 B**	**16.31 A**	**58.19 A**	**662.68 A**	**11.06 A**
100 % E_{pan}			**710.19 A**	**17.94 A**	**54.82 A**	**646.64 A**	**11.26 A**	**665.11 A**	**16.86 A**	**59.56 A**	**679.01 A**	**10.53 A**
Green Comet			**640.5 C**	**17.42 A**	**53.17 B**	**626.5 B**	**11.54 B**	**617.4 B**	**16.38 A**	**57.90 B**	**659.3 B**	**10.63 B**
Premium Crop			**698.7 A**	**17.50 A**	**53.56 B**	**632.0 B**	**12.02 A**	**658.6A**	**16.63 A**	**58.97 AB**	**671.9 AB**	**11.35 A**
Pinnacle			**665.9 B**	**17.88 A**	**55.51 A**	**654.7 A**	**11.07 C**	**626.3 B**	**16.75 A**	**59.77 A**	**681.4 A**	**10.40 B**
	½ NPK		**654.56 B**	**17.75 A**	**54.92 A**	**647.88 A**	**11.87 A**	**626.17 B**	**16.81 A**	**59.41 A**	**677.18 A**	**11.07 A**
	NPK		**682.17 A**	**17.44 A**	**53.24 A**	**627.57 A**	**11.22 A**	**642.00 A**	**16.36 A**	**58.35 A**	**664.51 A**	**10.52 A**
		Cont.	**519.78 B**	**15.61 B**	**48.36 B**	**570.24 B**	**12.70 A**	**487.44 B**	**14.61 B**	**52.51 B**	**598.09 B**	**12.07 A**
		Halex	**816.94 A**	**19.58 A**	**59.81 A**	**705.21 A**	**10.38 B**	**780.72 A**	**18.56 A**	**65.25 A**	**743.60 A**	**9.52 B**
Green Comet	**½ NPK**	**Cont**	**404.3 l**	**15.00 g**	**47.00 fg**	**554.6 fg**	**13.30 b**	**446.7 fg**	**13.67 f**	**51.00 h**	**581.4 h**	**12.80 abc**
		Halex	**741.0 f**	**19.67 ab**	**60.97 ab**	**718.1 ab**	**11.53 ghi**	**767.7 c**	**19.00 ab**	**66.87 abc**	**761.2 abc**	**10.47 fgh**
	NPK	**Cont**	**442.3 l**	**15.67 fg**	**48.70 fg**	**573.3 fg**	**12.83 bcde**	**400.7 g**	**14.33 ef**	**53.27 gh**	**603.9 gh**	**12.13 bcd**
		Halex	**794.3 de**	**18.00 cd**	**53.57 de**	**627.8 de**	**11.23 hijk**	**786.0 bc**	**17.00 d**	**60.30 def**	**685.8 ef**	**9.60 hij**

	Prinnium Crop	½ NPK	Cont	**498.0 jk**	**15.00 g**	**46.80 fg**	**552.3 fg**	**14.57 a**	**465.0 f**	**15.00 e**	**51.00 h**	**581.4 h**	**13.47 a**
			Halex	**806.7 cde**	**19.67 ab**	**60.63 ab**	**715.1 ab**	**12.17 defg**	**761.7 c**	**18.33 abc**	**66.87 abc**	**762.3 abc**	**11.97 bcd**
		NPK	Cont	**504.0 jk**	**16.67 ef**	**50.70 ef**	**598.4 ef**	**13.43 b**	**476.3 f**	**15.00 e**	**56.67 fg**	**643.2 fg**	**12.93 ab**
			Halex	**831.0 bcd**	**17.33 de**	**54.33 de**	**641.1 de**	**8.97 m**	**767.7 c**	**17.33 cd**	**58.87 ef**	**671.1 ef**	**8.400 kl**
	Pinnacle	½ NPK	Cont	**485.0 k**	**15.67 fg**	**49.17 fg**	**580.2 fg**	**13.03 bc**	**458.3 f**	**14.67 ef**	**51.67 h**	**589.0 h**	**12.20 bcd**
			Halex	**740.7 f**	**20.00 ab**	**61.67 ab**	**727.7 ab**	**9.40 m**	**699.0 d**	**19.00 ab**	**65.67 abc**	**748.6 abc**	**8.433 kl**
		NPK	Cont	**496.3 jk**	**15.33 g**	**47.53 fg**	**560.9 fg**	**12.10 efg**	**458.3 f**	**14.33 ef**	**52.13 h**	**594.3 h**	**11.47 def**
			Halex	**774.7 ef**	**19.00 bc**	**59.00 bc**	**696.2 bc**	**9.33 m**	**749.3 cd**	**18.00 bcd**	**64.03 cd**	**730.0 cd**	**8.87 ijk**
100 % E_{pan}	Green Comet	½ NPK	Cont	**521.3 jk**	**15.67 fg**	**48.57 fg**	**573.1 fg**	**12.33 cdef**	**444.3 fg**	**14.67 ef**	**51.17 h**	**583.3 h**	**12.17 bcd**
			Halex	**829.3 bcd**	**20.33 a**	**62.00 ab**	**731.6 ab**	**9.533 m**	**783.7 bc**	**19.00 ab**	**65.33 bc**	**744.8 bc**	**7.67 l**
		NPK	Cont	**534.7 ij**	**16.00 fg**	**49.03 fg**	**578.6 fg**	**11.93 fgh**	**486.0 f**	**15.00 e**	**54.40 gh**	**620.2gh**	**11.50 def**
			Halex	**857.0 b**	**19.00 bc**	**55.50 cd**	**654.9 cd**	**9.633 m**	**824.3 ab**	**18.33 abc**	**60.83 de**	**693.5 de**	**8.73 jk**
	Prinnium Crop	½ NPK	Cont	**577.0 gh**	**15.00 g**	**46.70 g**	**551.1 g**	**12.90 bcd**	**542.3 e**	**14.67 ef**	**51.13 h**	**583.1 h**	**11.90 bcd**
			Halex	**867.7 b**	**20.33 a**	**61.33 ab**	**723.7 ab**	**10.90 ijkl**	**834.0 ab**	**19.33 a**	**68.53 ab**	**781.3 ab**	**10.30 gh**
		NPK	Cont	**564.7 hi**	**15.67 fg**	**47.00 fg**	**554.6 fg**	**12.50 cdef**	**554.3 e**	**14.67 ef**	**51.00 h**	**581.4 h**	**11.83 cde**
			Halex	**940.3 a**	**20.33 a**	**61.00 ab**	**719.8 ab**	**10.73 jkl**	**867.3 a**	**18.67 ab**	**67.67 abc**	**771.4 abc**	**10.03 gh**
	Pinnacle	½ NPK	Cont	**603.7 gh**	**16.00 fg**	**50.50 efg**	**595.9 efg**	**12.03 fg**	**572.3 e**	**15.00 e**	**54.33 gh**	**619.4 gh**	**11.60 de**
			Halex	**780.0 ef**	**20.67 a**	**63.67 a**	**751.3 a**	**10.70 kl**	**739.0 cd**	**19.33 a**	**69.33 a**	**790.4 a**	**9.900 ghi**
		NPK	Cont	**606.0 g**	**15.67 fg**	**48.57 fg**	**570.0 fg**	**11.47 ghij**	**544.7 e**	**14.33 ef**	**52.33 h**	**596.6 h**	**10.83 efg**
			Halex	**840.7 bc**	**20.67 a**	**64.00 a**	**755.2 a**	**10.47 l**	**789.0 bc**	**19.33 a**	**68.67 ab**	**782.8 ab**	**9.900 ghi**

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character**

Table 4: Primary and secondry broccoli curds characteristics as influenced by the main and interaction effects of irrigation water quantities, cultivars, NPK rates and biofertilizer treatments during the seasons of 1999 and 2000.

Treatment				Average curd weight (g)	**Curd diam. (cm)**	Average curd weight g)	**Curd diam. (cm)**	**Curds no / plant**	Average curd weight(g)	**Curd diam. (cm)**	Average curd weight (g)	**Curd diam. (cm)**	**Curds no / plant**
				Primary curds		**Secondary curds**			**Primary curds**		**Secondary curds**		
				1999/2000					**2000/2001**				
75 % Epan				175.63 B	14.32 A	31.33 B	6.68 A	4.73 A	165.92B	12.85 B	30.16 B	6.17 A	4.27 A
100 % Epan				197.26A	17.05 B	35.51 A	6.95 A	3.98 B	184.78A	15.35 A	33.26 A	6.43 A	3.57 B
	Green Comet			180.3 C	15.21 B	32.03 C	6.64 B	4.23 B	169.1 C	13.83 B	30.88 B	6.12 B	3.838 B
	Premium Crop			194.1 A	15.44 B	34.94 A	6.73 B	4.30 B	182.9 A	13.72 B	32.93 A	6.32AB	3.817 B
	Pinnacle			184.9 B	16.40 A	33.30 B	7.07 A	4.55 A	174.0 B	14.75 A	31.33 B	6.46 A	4.100 A
		½NPK		189.49A	16.23 A	32.73 B	6.98 A	4.50 A	178.35A	14.53 A	31.32 B	6.4 A	4.03 A
		NPK		183.40 B	15.14 B	34.11 A	6.65 B	4.21 B	172.35B	13.68 B	32.11 A	6.2 B	3.80 B
			Cont	145.36 B	13.01 B	26.00 B	5.77 B	3.62 B	134.44B	11.64 B	24.38 B	5.17 B	3.23 B
			Halex	227.53A	18.36 A	40.84 A	7.86 A	5.09 A	216.25A	16.56 A	39.04 A	7.43 A	4.60 A
75 % Epan	**Green Comet**	½NPK	**Cont**	123.0 m	11.60 l	20.23 l	5.53 gh	3.73 k	111.3 g	10.23lmn	22.30 fg	4.9 h	3.33 ij
			Halex	220.7 de	17.67 fg	37.03 f	8.07 ab	5.37bcd	218.3 bc	14.87 efg	38.40 c	7.7 abc	4.97 a
		NPK	**Cont**	124.0 lm	10.37 n	22.13 l	5.83 gh	3.57 kl	112.3 g	9.50 mn	20.07 g	5.27 gh	3.47 hi
			Halex	213.3 ef	16.80 gh	39.73de	6.63def	5.47 abc	205.8 cd	15.93 de	39.30 bc	6.53 e	4.93 ab
	Premium Crop	½NPK	**Cont**	140.0 jk	11.57 lm	24.90 jk	5.5 gh	4.30 j	132.3 f	10.00lmn	23.27 f	4.9 h	3.73 gh
			Halex	230.8bcd	18.10 ef	40.33cde	8.03 ab	5.63 ab	213.2 c	16.53 cd	38.07 c	7.7 abc	5.13 a
		NPK	**Cont**	138.3 jk	10.47 mn	25.23 jk	6.2 efg	3.73 k	129.2 f	9.13 n	23.83 f	5.87 fg	3.10 jk
			Halex	224.0cde	15.93 hi	41.53bcd	6.87 de	5.10 def	211.5 c	14.43 gh	38.40 c	6.3 ef	4.63bcd
	Pinnacle	½NPK	**Cont**	137.8 jk	12.80 jk	24.27 k	5.93fgh	4.50 ij	127.3 f	12.40 ij	22.97 f	5.03 h	4.10 ef
			Halex	215.2 ef	17.50 fg	37.03 f	8.2 ab	5.70 a	208.2 cd	15.63 def	34.97 d	7.5 bc	5.03 a
		NPK	**Cont**	134.7 kl	12.10 kl	24.83 jk	5.6 gh	4.40 ij	127.3 f	10.63 lm	22.90 f	5.1 h	3.90 fg
			Halex	205.7 f	16.93 gh	38.73 ef	7.73 bc	5.30 cde	194.2 d	14.93 efg	37.47 cd	7.2 cd	4.90abc
100 % Epan	**Green Comet**	½NPK	**Cont**	148.5 ij	13.43 j	26.07 jk	5.8 gh	3.23 mn	135.0 f	12.03 jk	22.23 fg	4.93 h	2.83 klm
			Halex	238.0 b	19.30 bcd	41.47bcd	8.3 ab	4.90 fgh	229.0 ab	17.90 a	39.17 bc	7.47 bc	4.13 ef
		NPK	**Cont**	144.8 jk	12.83 jk	26.73 ij	5.9 gh	2.87 o	123.5 fg	12.47 ij	24.30 f	5.5 gh	2.63 lm
			Halex	230.3bcd	19.67 abc	42.83 b	7.07 cd	4.67 hi	217.7 bc	17.73 ab	41.23 ab	6.67 de	4.40 de
	Premium Crop	½NPK	**Cont**	156.8 hi	15.53 i	28.87 gh	5.47 h	3.20 mn	154.0 e	13.53 hi	27.13 e	4.93 h	2.77 lm
			Halex	261.2 a	20.30 ab	43.40 b	8.13 ab	5.00 efg	241.0 a	18.40 a	41.70 ab	8.03 ab	4.60 cd
		NPK	**Cont**	160.3 gh	13.30 j	28.23 hi	5.53 gh	2.93 no	150.7 e	11.13 kl	27.70 e	4.93 h	2.57 m
			Halex	241.0 b	18.30 def	47.00 a	8.07 ab	4.47 ij	231.7 ab	16.60 bcd	43.37 a	7.87 ab	4.00 fg
	Pinnacle	½NPK	**Cont**	168.3 g	16.30 hi	30.20 gh	6.17e-h	3.57 kl	151.3 e	14.67 fgh	28.63 e	5.5 gh	3.43 hi
			Halex	233.5 bc	20.60 a	39.00 ef	8.57 a	4.83 fgh	219.2 bc	18.13 a	36.97 cd	8.17 a	4.33 de
		NPK	**Cont**	167.7 gh	15.83 hi	30.30 g	5.77 gh	3.37 lm	159.0 e	14.00 gh	27.23 e	5.17 h	2.93 kl
			Halex	216.7 e	19.17 cde	42.03 bc	8.63 a	4.70 ghi	205.3 cd	17.63 abc	39.47 bc	8.03 ab	4.17 ef

***Values marked with the same letter (s) are statistically similar using LSD test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character**

Table 6. Influence of main and interactions of irrigation water quantities, cultivars, NPK rates and biofertilizer treatments on the N and P contents of curd, stem and leaves of broccoli during the seasons of 1999 and 2000.

Treatments				N (g/100 g dry weight)			P (g/100 g dry weight)			N (g/100 g dry weight)			P (g/100 g dry weight)		
				Curd	Stem	Leaves	Curd	Stem	Leaves	Curd	Stem	Leaves	Curd	Stem	Leaves
				1999/2000						2000/2001					
75 % Epan				2.51 B	1.77 B	3.30 B	0.445 A	0.287 A	0.366 A	2.37 B	1.68 B	3.14 B	0.417 A	0.256 A	0.342 A
100 % Epan				2.82 A	1.99 A	3.74 A	0.445	0.239 B	0.32 5 B	2.64 A	1.87 A	3.58 A	0.419 A	0.214 B	0.306 B
	Green Comet			2.58 C	1.82 C	3.36 C	0.439 B	0.258 B	0.332 C	2.41 C	1.71 C	3.23 B	0.411 B	0.231 B	0.310 C
	Premium Crop			2.77 A	1.96 A	3.55 B	0.476 A	0.257 B	0.358 A	2.61 A	1.85 A	3.43 A	0.449 A	0.229 B	0.338 A
	Pinnacle			2.64 B	1.87 B	3.66 A	0.420 C	0.273 A	0.345 B	2.49 B	1.76 B	3.40A	0.395 B	0.246 A	0.324 B
		½ NPK		2.62 B	1.85 B	3.47 B	0.450 A	0.273 A	0.350 A	2.46 B	1.74 B	3.30 B	0.424 A	0.243 B	0.329 A
		NPK		2.71 A	1.91 A	3.58 A	0.440 A	0.252 B	0.340 B	2.55 A	1.80 A	3.41 A	0.413 A	0.227 A	0.319 B
			Cont.	2.08 B	1.47 B	2.60 B	0.412 B	0.220 B	0.317 B	1.92 B	1.36 B	2.40 B	0.383 B	0.194 B	0.293 B
			Halex	3.25 A	2.30 A	4.45 A	0.477 A	0.306 A	0.373 A	3.09 A	2.18 A	4.31 A	0.454 A	0.276 A	0.354 A
75 % Epan	Green Comet	½ NPK	Cont	1.77 lm	1.253 n	2.213 j	0.439 hij	0.258 h	0.323 fg	1.61 g	1.135 g	2.007 k	0.414 def	0.208 ij	0.294 g
			Halex	3.05 ef	2.155 gh	4.267 def	0.454 e-i	0.322 abc	0.389 b	2.94 cd	2.079 cd	4.117 efg	0.437 b-e	0.295 ab	0.375 abc
		NPK	Cont	1.76 m	1.243 n	2.197 j	0.444 g-j	0.214 i	0.316 gh	1.59 g	1.125 g	1.987 k	0.379 fgh	0.201 jk	0.269 gh
			Halex	3.15 de	2.229 efg	4.413 cd	0.440 hij	0.328 ab	0.377 bc	3.12 bc	2.205 bc	4.367 cde	0.415def	0.298 a	0.356 b-e
	Prinnium Crop	½ NPK	Cont	1.98 jk	1.397 lm	2.470 ij	0.481 b-f	0.259 h	0.342 ef	1.85 f	1.304 f	2.310 j	0.473 ab	0.226 hi	0.336 def
			Halex	3.20 cde	2.263 def	4.003 f	0.498 ab	0.338 a	0.427 a	3.02 c	2.136 c	3.773 h	0.460 a-d	0.307 a	0.394 a
		NPK	Cont	2.00 jk	1.414 lm	2.500 i	0.492 a-d	0.222 i	0.349 de	1.89 f	1.337 f	2.363 j	0.462 a-d	0.186 kl	0.328 f
			Halex	3.30 bcd	2.332 b-e	4.293 de	0.46 d-i	0.305 bcd	0.395 b	3.05 c	2.153 c	4.110 fg	0.442 a-e	0.276 bcd	0.379 ab
	Pinnacle	½ NPK	Cont	1.92 kl	1.360 m	2.407 ij	0.378 kl	0.272 e-h	0.367 cd	1.82 f	1.286 f	2.277 j	0.340 hi	0.245 fgh	0.330 ef
			Halex	2.94 f	2.077 h	4.113 ef	0.446 hij	0.343 a	0.382 bc	2.77 d	1.961 d	3.883 gh	0.418 c-f	0.302 a	0.359 bcd
		NPK	Cont	1.97 jk	1.392 m	2.463 ij	0.320 m	0.264 gh	0.365 cd	1.82 f	1.286 f	2.270 j	0.303 i	0.233 gh	0.346 def
			Halex	3.07 ef	2.173 fgh	4.303 de	0.487 a-e	0.320 abc	0.355 de	2.97 cd	2.103 cd	4.163 def	0.461 a-d	0.294 abc	0.336 def
100 % Epan	Green Comet	½ NPK	Cont	2.07 jk	1.463 lm	2.587 hi	0.377 kl	0.193 ij	0.268 j	1.76 fg	1.248 fg	2.207 jk	0.342 hi	0.159mn	0.243 h
			Halex	3.29 bcd	2.326cde	4.113 ef	0.496 bc	0.294 c-f	0.361 cde	3.11 bc	2.199 bc	4.353 c-f	0.490 a	0.266 de	0.357bcd
		NPK	Cont	2.12 ij	1.500 kl	2.650 hi	0.380 kl	0.173 j	0.270 j	1.89 f	1.364 f	2.410 j	0.345 ghi	0.170lm	0.245 h
			Halex	3.40 b	2.404 bc	4.423 cd	0.479 b-g	0.280 d-h	0.349 de	3.27 ab	2.313 ab	4.417bcd	0.462 a-d	0.248 fg	0.337def
	Prinnium Crop	½ NPK	Cont	2.29 gh	1.620 ij	2.863 gh	0.430 hij	0.193 ij	0.305 ghi	2.15 e	1.522 e	2.690 i	0.406 ef	0.167lm	0.288 g
			Halex	3.44 b	2.434 b	4.820 b	0.519 a	0.302 b-e	0.378 bc	3.31 ab	2.340 ab	4.633 ab	0.479 ab	0.275 cd	0.349 c-f
		NPK	Cont	2.24 hi	1.584 jk	2.803 gh	0.424 ij	0.174 j	0.301 hi	2.20 e	1.556 e	2.750 i	0.396 efg	0.152 n	0.282 g
			Halex	3.73 a	2.638 a	4.663 bc	0.503 ab	0.265 fgh	0.367 cd	3.44 a	2.435 a	4.820 a	0.475 ab	0.241gh	0.346def
	Pinnacle	½ NPK	Cont	2.40 gh	1.693 i	2.993 g	0.413 jk	0.213 I	0.300 hi	2.27 e	1.606 e	2.840 i	0.391 e-h	0.207 ij	0.277 g
			Halex	3.10 e	2.188 fg	4.813 b	0.462 c-h	0.292 c-g	0.352 de	2.93 cd	2.074 cd	4.563 bc	0.436 b-e	0.261def	0.341 def
		NPK	Cont	2.41 g	1.700 i	3.007 g	0.367 l	0.201 ij	0.293 i	2.16 e	1.529 e	2.703 i	0.343 hi	0.177 lm	0.278 g
			Halex	3.34 bc	2.358 bcd	5.187 a	0.484 a-e	0.282 d-h	0.342 ef	3.13 bc	2.214 bc	4.523 bc	0.468 abc	0.249efg	0.323 f

***Values marked with the same letter (s) are statistically similar using LSD test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**

Table 7. Influence of irrigation water quantities, cultivars, NPK rates and biofertilizer treatments on potassium and ascorbic acid contents of broccoli during the growing seasons of 1999 and 2000.

Treatments				K (g/100 g dry weight)			Ascorbic acid (g/100 g fresh weight)			K (g/100 g dry weight)			Ascorbic acid (g/100 g fresh weight)		
				Curd	**Stem**	**Leaves**	**Curd**	**Stem**	**Leaves**	**Curd**	**Stem**	**Leaves**	**Curd**	**Stem**	**Leaves**
				1999/2000						**2000/20001**					
75 % Epan				2.411 A	4.597 A	3.202 A	104.29 A	124.38 A	76.82 A	2.285 A	4.316 A	2.988 A	97.52 A	116.33 A	71.82 A
100 % Epan				2.137 B	4.322 B	2.811 B	99.54 B	116.62 B	68.08 B	2.016 B	4.073 A	2.643 B	93.93 B	110.03 B	64.18 B
	Green Comet			2.193 C	4.312 C	2.878 C	97.53 C	112.80 C	69.65 C	2.093 B	4.017 C	2.666 C	91.10 C	105.30 B	64.93 C
	Premium Crop			2.364 A	4.618 A	3.116 A	105.1A	125.20 A	75.17 A	2.230 A	4.382 A	2.945 A	99.17 A	118.10 A	70.94 A
	Pinnacle			2.265 B	4.448 B	3.025 B	103.1 B	123.50 B	72.53 B	2.129 B	4.184 B	2.836 B	96.89 B	116.10 A	68.12 B
		½ NPK		2.309 A	4.535 A	3.045 A	103.44 A	122.82 A	73.43 A	2.176 A	4.298 A	2.856 A	97.79 A	115.51 A	68.98 A
		NPK		2.239 B	4.384 B	2.968 B	100.39 B	118.18 B	71.48 B	2.125 A	4.091 B	2.776 B	93.65 B	110.84 B	67.01 B
			Cont.	1.991 B	4.162 B	3.304 A	90.85 B	107.68 B	67.12 B	1.842 B	3.851 B	3.056 A	84.03 B	99.59 B	62.07 B
			Halex	2.557 A	4.757 A	2.709 B	112.98 A	133.32 A	77.79 A	2.459 A	4.537 A	2.575 B	107.42 A	126.77 A	73.93 A
	Green Comet	**½ NPK**	Cont	2.034 ij	4.370 def	3.377 cd	92.8 hi	110.0 kl	69.07 hij	1.692 ij	3.970 c	3.070 b	84.38 g	100.0 gh	62.79 e
			Halex	2.674 b	4.760 abc	2.833 hi	107.7 de	119.0 ij	80.68 bc	2.799 a	4.580 ab	2.727 d-g	103.6 cde	114.5 ef	77.63 abc

		NPK	Cont	1.984 jk	4.260 efg	3.293 de	90.5 ij	107.3 lm	67.36 ij	1.849 i	3.633 cd	2.807 cde	77.19 gh	91.48 hi	57.44 efg
			Halex	2.588 bcd	4.607 cd	2.740h-m	104.2 efg	115.2 jk	78.08 b-f	2.573 bcd	4.353 b	2.590 e-h	98.49 def	108.8 fg	73.78 bcd
	Prinniu Crop	½ NPK	Cont	2.148 hi	4.613 bcd	3.567 bc	98.0 gh	118.8 ij	72.95 fgh	2.109 gh	4.530 ab	3.503 a	96.25 ef	111.6 ef	71.63 cd
			Halex	2.935 a	4.930 a	3.110 ef	118.2 ab	148.8 a	88.53 a	2.708 ab	4.733 a	2.870 bcd	109.1 abc	143.0 a	81.69 a
		NPK	Cont	2.196 gh	4.713 abc	3.643 ab	100.2 fg	116.2 jk	74.57 d-g	2.064 h	4.430 ab	3.427 a	94.2 f	114.1 ef	70.08 d
			Halex	2.708 b	4.820 abc	2.870 gh	109.0 cde	130.6 e-h	81.69 b	2.603 abc	4.633 ab	2.760 c-f	104.8 bcd	120.5 cde	78.53 ab
	Pinnacle	½ NPK	Cont	2.306 fg	4.930 a	3.823 a	104.8 ef	124.7 ghi	78.29 b-e	2.073 h	4.673 ab	3.440 a	99.38 def	112.1 ef	70.39 d
			Halex	2.624 bc	4.610 bcd	2.780 h-k	115.1 bc	144.1 ab	79.16 bcd	2.463 cde	4.370 ab	2.607 e-h	109.1 abc	135.3 ab	74.29 bcd
		NPK	Cont	2.297 fg	3.583 i	3.810 a	105.2 ef	124.2 hi	77.98 b-f	2.178 fgh	3.220 e	3.613 a	94.58 f	117.8 def	73.95 bcd
			Halex	2.434 ef	4.967 a	2.580 k-n	105.7 ef	133.7 def	73.45 e-h	2.307 efg	4.663 ab	2.447 hi	99.2 def	126.8 bcd	69.60 d
100 % Epan	Green Comet	½ NPK	Cont	1.685 m	3.620 i	2.793 hij	76.88 l	91.11 o	57.21 k	1.525 j	3.273 de	2.530 f-i	69.58 h	82.47 i	51.78 g
			Halex	2.479 de	4.693 abc	2.627 j-n	117.2 ab	136.2 cde	74.80 d-g	2.453 cde	4.647 ab	2.600 e-h	116.0 a	134.8 ab	74.01 bcd
		NPK	Cont	1.699 m	3.647 i	2.820 hij	77.50 l	91.85 o	57.67 k	1.539 j	3.303 de	2.553 e-i	70.21 h	83.21 i	52.25 g
			Halex	2.397 ef	4.540 cde	2.540 mn	113.3 bcd	131.7 d-g	72.32 ghi	2.313 ef	4.377 ab	2.453 hi	109.4 abc	127.1 bcd	69.78 d
	Prinniu Crop	½ NPK	Cont	1.918 jkl	4.120 fgh	3.183 def	87.50 ijk	103.7 lmn	65.12 j	1.813 i	3.893 c	3.010 bc	82.71 g	98.02 h	61.55 e
			Halex	2.594 bcd	4.913 a	2.747 h-l	122.6 a	142.5 abc	78.25 b-e	2.395 de	4.537 ab	2.537 f-i	113.3 a	131.6 b	72.26 cd
		NPK	Cont	1.895 kl	4.070 gh	3.143 ef	86.46 jk	102.5 mn	64.34 j	1.769 i	3.797 c	2.933 bcd	80.73 g	95.68 h	60.08 e
			Halex	2.517 cde	4.763 abc	2.667 i-m	119.0 ab	138.3 bcd	75.93 c-g	2.377 def	4.500 ab	2.517 f-i	112.4 ab	130.6 b	71.69 cd
	Pinnacle	½ NPK	Cont	1.888 kl	3.963 h	3.133 ef	86.2 jk	102.1 mn	64.11 j	1.744 i	3.747 c	2.893 bcd	79.58 g	94.32 h	59.22 ef
			Halex	2.418 ef	4.897 ab	2.563 lmn	114.3 bc	132.8 def	72.94 fgh	2.339 ef	4.620 ab	2.480 ghi	110.6 abc	128.5 bc	70.57 d
		NPK	Cont	1.845 l	4.053 gh	3.060 fg	84.2 k	99.75 n	56.71 k	1.744 i	3.747 c	2.893 bcd	79.58 g	94.32 h	53.66 fg
			Halex	2.311 fg	4.580 cd	2.450 n	109.3 cde	127.0 fgh	77.61 b-f	2.182 fgh	4.430 ab	2.313 i	103.2 cde	119.9 cde	73.27 bcd

***Values marked with the same letter (s) are statistically similar using LSD test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**