Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(6): 2234-2237
Received: 19-09-2017
Accepted: 20-10-2017

M Choudhary
Department of Horticulture, S.k.n. College of Agriculture, Jobner, Jaipur, Rajasthan, India

RK Jat
Department of Horticulture, S.k.n. College of Agriculture, Jobner, Jaipur, Rajasthan, India

P chand
Department of Horticulture, S.k.n. College of Agriculture, Jobner, Jaipur, Rajasthan, India

R Choudhary
Department of Horticulture, S.k.n. College of Agriculture, Jobner, Jaipur, Rajasthan, India

Correspondence
M Choudhary
Department of Horticulture, S.k.n. College of Agriculture, Jobner, Jaipur, Rajasthan, India

Effect of bio-fertilizers on growth, yield and quality of knol-khol

M Choudhary, RK Jat, P chand and R Choudhary

Abstract
An experiment was conducted in Randomized Block Design at Horticulture farm, S.K.N. College of Agriculture, Jobner during *rabi* season of 2009-10 to study the effect of biofertilizers *Azospirillum, Azotobacter* and PSB and different fertility levels of NPK on growth, yield and quality of Knol-khol (*Brassica caulorapa* L.). The experiment consist of 16 treatment combinations *viz.*, four levels of fertility (control, 50%, 75% and 100% recommended dose of NPK) and four different biofertilizer inoculations (control, *Azotobactor*, Azospirillum and PSB). Among different bio-fertilizers the inoculation of PSB leads to maximum plant height, number of leaves per plant, knob diameter, biological yield per plant, average weight of knob, volume of knob, yield of knob per hectare, NPK content in Knob, protein content, ascorbic acid and chlorophyll content over rest of Biofertilizers but at par with *Azospirillum*. The inoculation of *Azotobacter* also recorded better performance. These bacterial inoculants responded to with an increase in growth, yield and quality parameters as compared to control. So, better results were obtained by the application biofertilizer inoculants.

Keywords: Knol-khol, Biofertilizers, Nitrogen, Phosphorus, Potassium, PSB, Azospirillum, Azotobacter, Recommended dose

Introduction
Knol-khol (*Brassica caulorapa* L.) is an important member of Cruciferae. Knol-khol (*Brassica caulorapa* L.) is a winter season crop and is originated from the coastal countries of Mediterranean region. It has been under cultivation by Romans since 600 B.C. (Bose, 2001) [3]. In India, the cultivation of knol-khol is popular in Kashmir, West Bengal and some parts of South India. It is commonly grown in Northern India and also in some parts of Rajasthan.

Vegetable production needs proper strategies to ensure round the year availability to the increasing population at reasonable prices besides safeguarding the interest to the farmers. The indiscriminate use of the chemical fertilizers has simultaneously resulted in many problems. Hence, approach of integrated plant nutrient system aims at sustaining productivity with minimum deleterious effects of chemicals on soil health, environment & human health as well. Application of bio-fertilizers inoculation in vegetable crops has been of much significance as *Azotobacter* and *Azospirillum* for atmospheric nitrogen, also known for synthesis of biologically growth promoting substances whereas, PSB are important microbes in releasing and making available phosphorus by colonizing the root surface of growing plant root. They also improve the plant growth due to increase in nutrient uptake particularly phosphorus, zinc and other micro-nutrients, production of growth promoting substances and resistance to plant pathogen. These bio-fertilizers are organic in origin and thus, are absolutely safe. Therefore, it is essential to adopt a strategy of integrated nutrient management using combination of chemical fertilizers, organic manures and biofertilizers, so as to minimize the cost of production and to maintain biological productivity of soils, particularly because the farmers are reluctant to adopt recommended fertilizer doses due to the high cost and risk of crop failures on account of aberrant weather conditions. The integrated nutrient management supply system provides crop nutrition packages, which are technically sound, economically viable, practically feasible and environmentally safe. The information on use of biofertilizers on vegetables is very meagre for the soils of Rajasthan. Hence, keeping all the points in view, the present study "Effect of biofertilizers on growth, yield and quality of knol-khol (*Brassica caulorapa* L.)" was undertaken.

Materials and methods
Location of experiment
The experiment was conducted at Horticulture farm, S.K.N. College of Agriculture, Jobner, district Jaipur (Rajasthan)

Jobner is situated at 26º 5' North latitude and 75º 28' East longitudes at an elevation of 427 metres above mean sea level. The place falls in agroclimatic zone III-A (semi-arid eastern plain zone) of Rajasthan.

Treatment Details

Boiferilizer *viz.* PSB, *Azospirillum*, *Azotobacter* and control used as a treatment which is denoted as B_1 (Azotobacter), B_2 (Azospirillum), B_3 (PSB) and B_0 (Control) in this experiment.

Obsevations

Observations on five randomly selected plants from each replication were recorded for Plant height (cm), Average number of leaves per plant, Diameter of knob (cm), Biological yield per plant (g), Average weight of knob (g), Volume of knob (cc), yield of knob per ha (q), NPK content in knob (%), Protein content in knob (%), Ascorbic acid in knob (mg / 100 g) and Chlorophyll content (mg/g fresh weight).

Methodology

Plant height was recorded at 45 days and at harvest. Height of five tagged plants were recorded from base level to the apex of the longest leaf with the help of scale and average height was calculated. The average number of leaves of five tagged plants were counted from each plot at 45 days and at harvest and the average number of leaves per plant was calculated. Diameter of knob was measured by vernier caliper at maximum growth portion. Biological yield per plant (g) was calculated as tagged plants were weighed at the time of harvesting and average weight per plant was calculated. Average weight of 10 knob was recorded after removing leaves. Volume of knob was recorded by measuring the displaced water which was obtained by dipping the knob in a measuring cylinder and volume was calculated in cc. On the basis of knob yield per bed the yield per hectare was estimated. Nitrogen content in the knob was estimated by using Nesselar's reagent by spectrophotometer method (Snell and Snell, 1949) [14]. Phosphorus was estimated by spectrophotometer method using Triacid ammonium molybdnate ammonium vabnadete solution (Jackson, 1967) [6]. Potassium content in knob was estimated by using flame photometer method using triacid (Richards, 1954) [10]. The knob portions was analysed separately for nitrogen content (%) by colorimetric method (Snell and Snell, 1949) [14]. Nitrogen content is multiplied with 6.25 factor to calculate crude protein content in knob. Ascorbic acid content of knob was determined by diluting the known volume of juice with 3% meta-phosphoric acid and titrating with 2, 6-dichlorophenol-indo phenol solution (A.O.A.C., 1960) [1], till the faint pink colour was obtained. chlorophyll content was determined using the method of Hiscox and Israelstom (1979) [5] with slight modifications. 50 mg fresh leaf material was used for chlorophyll estimation. The material was taken in test tube to which 5.0 ml Dimethyl Sulphoxide was added. These tubes were tightly capped and placed in an oven at 60^0C for 6 hrs. Finally the tubes were thoroughly shaken and extracted solvent was decantated to read absorbance at 645 and 663 nm by spectrophotometer (Systronics, India). The amount of total chlorophyll was calculated as advocated by Arnon (1949) [2].

Statistical Analysis

To test the significance of variation in data obtained from various growth, yield and quality characters, the technique of analysis of variance was adopted as suggested by Fisher (1950) for randomized block design. Significance of difference in the treatment effect was tested through 'F' test at 5 per cent level of significance and CD (critical difference) was calculated, wherever the results were significant.

Result and Discussion

Effect of biofertilizers

Growth attributes

Data on various growth attributes revealed that application of biofertilizers increasing the plant height, number of leaves per plant and diameter of knob (Table 1). Seed inoculation with PSB recorded the maximum plant height at 45 Das (24.32 cm) and at harvest (28.33 cm) which was statistically at par with *Azospirillium* and *Azotobacter* at 45 DAs. The increase in plant height due to PSB was 21.17 and 6.80 per cent at 45 DAS and 19.73 and 7.06 per cent at harvest over control and *Azotobacter*, respectively. The number of leaves was affected by biofertilizers at 45 DAS and at harvest. Significantly and the maximum number of leaves at 45 DAS (20.30) and at harvest (25.82) was found in B_3 (PSB) which was significantly higher over control but statistically at par with B_2 (*Azospirillium*) and B_3 (PSB). The different biofertilizers treatment also significant influenced the diameter of knob. The maximum diameter of knob (6.42 cm) was found under B_3 (PSB) which was significantly higher over control and B_1 (Azotobactor) but statistically at par with B_2 (*Azospirillium*). The mean increase in diameter of knob under the treatment B_3 recorded 27.88 and 8.26 per cent diameter over B_0 (Control) and B_1(Azotobactor), respectively. Since phosphorus is one of the essential nutrient and it's availability in an adequate amount leads to better growth and reproduction in the plants. Inoculation with PSB enhances its availability through solubilization of insoluble phosphorus through excretion of organic acids like succinic, lactic, oxalic, glioxalic malic, formalic, ∝-ketobutyric, propenic, formic, 2-ketogluconic acid etc. Out of these lactic and 2-ketogluconic acids acts as chelaters of calcium. Adequate utilization due to direct supply and / or solubilzing of native and added phosphorus by the PSB microorganisms at early stages of plant life played a vital role in laying down the root primodia for a reproductive portion (Rodriguez and Fraga, 1999) [11]. In addition to solubilization, these microbs mineralized organic phosphorus in soluble form and also improves availability of phosphorus in alkaline soils (Kumawat, 2008) [7]. these results are inclose conformity with the findings of Singh (2008) [15] in cauliflower and Kumawat (2009) [8] in cabbage.

Yield attributes and yield

Data on various yield attributes and yield revealed that application of biofertilizers increasing the biological yield, average weight of knob, volume of knob, yield of knob per hectare (Table 2).

Biofertilizers treatment also significantly affected the biological yield (199.99 g) and maximum was recorded with the treatment B_3 (PSB) followed by (Azospirillum) B_2 (196.34 g) and (Azotobacter) B_1 (186.64 g), while minimum was in (Control) B_0 (164.69 g) treatments. The treatment B_3 (PSB) was found significantly superior over control but statistically at with B_1 (Azotobacter) and B_2 (Azospirillum). The increase in the biological yield per plant by the treatment B_3 (PSB) recorded to be 21.43 per cent and 7.15 per cent higher over B_0 (Control) and B_1 (Azotobacter), treatment, respectively. The maximum average weight of knob (129.01 g) was with B_3 (PSB), which was significantly higher over B_0 (control) but remained at par with B_1 (Azotobacter) and B_2 (Azospirillum). The per cent increase in average weight of knob B_3 (PSB) was

to be 30.01 and 6.86 per cent, over control, respectively. The maximum volume of knob was found in B_3 (PSB) which was significantly superior over B_0 (Control) but statistically at par with B_1 (Azotobacter) and B_2 (Azospirillum). The maximum volume of knob recorded under the treatment B_3 (PSB) which was 32.26, 8.08 and 3.39 per cent higher over B_0, B_1 and B_2, respectively. The maximum knob yield (162.91 q ha^{-1}) was recorded under treatment B_3 (PSB) followed by (Azospirillum) B_2 (158.04 q ha^{-1}) and (Azotobacter) B_1 (150.32 q ha^{-1}), while minimum under (Control) B_0 (126.84 q ha^{-1}). The treatment B_3 (PSB) was found significantly superior over control and B_1(Azotobacter) but statistically at par with B_2 (Azospirillum). The increase in the knob yield by 28.43, 8.37 and 3.08 per cent higher over B_0, B_1 and B_2 treatment, respectively due to B_3. The improvement in yield characters in knol-khol with inoculation of PSB is due to solubilization and increased availability of phosphorus from insoluble or otherwise fixed phosphorus for its plant availability (Hedgi *et al*., 1999) [4]. The beneficial effects of PSB along with other nutrients increased yield of crop might have resulted due to higher rate in partitioning of different reproductive structure and yield attributes which might have ultimately inturned to higher yield of the crop. These findings corroborate the results of Vimala and Natrajan (2000) [16] and singh (2008) [15], Kumawat (2008) [7] and Kumawat (2009) [8].

Quality parameter

Data on various quality parameters revealed that application of biofertilizers increasing the N,P, and K content, protein content, ascorbic acid content and chlorophyll content (Table). The maximum N content (2.92%) was recorded under the treatment B_3 (PSB) while, minimum (2.57%) under B_0 (Control). all biofertilizers was found significantly higher over control but remained statistically at par with each other. The mean increase in N content under B_3 (PSB) treatment was found to be 13.61 per cent over control. The maximum P content (0.53%) was recorded under B_3(PSB) treatment which was superior over B_0 and B_1. The increase in P content due to B_3 (PSB) was 26.19, 10.41 and 6.0 per cent over B_0(Control), B_1 (Azotobacter) and B_2 (Azospirillum), respectively. The maximum K content (3.05%) was recorded with the treatment PSB, while minimum (2.71%) was recorded under B_0. all biofertilizers treatments were found to be significantly at par with each other. The K content due to the treatment B_3 (PSB) was found to be 12.54 per cent higher over control. The maximum protein content (18.23%) was recorded with PSB which was significantly higher over B_0 (Control) but remained statistically at par with B_1 (Azotobacter) and B_2 (Azospirillum). The protein content increased due to B_3 (PSB) was 13.51 per cent over control. The maximum ascorbic acid content in knob was found in B_3 (PSB) which was significantly higher to B_0 (Control) but was statistically at par with B_1 (Azotobacter) and B_2 (Azospirillum). the maximum ascorbic acid content in knob recorded under the treatment B_3 (PSB) indicating 22.82 per cent higher ascorbic acid content as compared to control. The maximum chlorophyll content (0.87 mg/g) was recorded under the treatment B_3 (PSB), while minimum number under B_0 (Control) (0.74 mg/g). The treatment B_3(PSB) was found significantly superior over control but remained statistically at par with B_1 (Azotobacter) and B_2 (Azospirillum). The mean increase in chlorophyll content in leaves due to the treatment B_2 (Azospirillum) was 17.57 per cent over control (B_0). the maximum increasing N, P and K content in knob, protein content, ascorbic acid and total chlorophyll content in leaves at 45 DAS where recorded with the inoculation of PSB which is significant over control but being at par with Azospirillum and Azotobactor which might be due to improved nutrient availability in the root zone and solubilization of the native phosphate in soil by PSB. Phosphorus solubilizing bacteria enhances the availability of phosphorus to plants and gives rise to better utilization of nutrients by the crop which might have inturn greater root development and plant height. Thus, the increase in availability of N and P might have resulted in greater content and uptake in broccoli head (Rusal, 1996, and Sable and Bhamare, 2007) [12, 13]. The nutrient content in head is due to higher functional activity of microbes in the root zone for longer duration under inoculation of PSB and VAM (Mukherjee and Rai, 2000) [9].

Table 1: Effect of Biofertilizers on Growth attributes.

Treatments	Plant height (cm)		Number of leaves per plant		Knob diameter (cm)
	45 DAT	At harvest	45 DAT	At harvest	At harvest
Control	20.07	23.66	16.93	21.35	5.02
azotobacter	22.77	26.46	19.20	23.93	5.93
Azospirillum	23.58	27.45	19.78	25.20	6.24
PSB	24.32	28.33	20.30	25.82	6.42
S.Em±	0.52	0.62	0.45	0.57	0.14
CD (P = 0.05)	1.50	1.80	1.31	1.63	0.40

Table 2: Effect of Biofertilizers on yield attributes and yield.

Treatments	Biological yield per plant	Average weight of knob	Volume of knob (cc)	Yield of knob (q/ha)
Control	164.69	99.15	84.33	126.84
azotobacter	186.64	120.72	103.20	150.32
Azospirillum	196.34	125.89	107.88	158.04
PSB	199.99	129.01	111.54	162.91
S.Em±	4.41	2.82	2.40	3.52
CD (P = 0.05)	12.75	8.15	6.93	10.15

Table 3: Effect Biofertilizers on Quality attributes.

Treatments	N Conten (%)	P Content (%)	K Content (%)	Protein content (%)	Ascorbic acid (%)	Total chlorophyll content (mg /g fresh weight)
Control	2.57	0.42	2.71	16.06	26.24	0.74
azotobacter	2.82	0.48	2.96	17.64	30.18	0.83
Azospirillum	2.89	0.50	3.02	18.03	31.01	0.86
PSB	2.92	0.53	3.05	18.23	32.23	0.87
S.Em+	0.07	0.01	0.07	0.42	0.71	0.02
CD (P = 0.05)	0.19	0.03	0.20	1.20	2.05	0.06

Conclusion

On the basis of this study, it can be concluded that PSB, Azospirillum and Azotobactor recorded significantly higher yield and net return of the crop. Thus, the study indicated that application of bioferilizers not only improved the productivity of knol-khol but also gave maximum monitory benefit.

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