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Effect of inorganic nutrients and biofertilizers on quality of spinach beet (*Beta vulgaris* var *bengalensis*) Cv. Pusa Bharati

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Abstract
A field experiment was laid out to study the effect of inorganic nutrients and biofertilizers on quality of spinach beet during *rabi*, 2020-2021 at PG research farm, College of Horticulture, Rajendranagar, Hyderabad. The ten integrated treatments consisting of inorganic nutrients, biofertilizers and Arka vegetable special were arranged in a randomized block design with three replications. Results revealed that maximum Vitamin- C (65.70 mg 100 g-1), Carotene content (10.59 mg 100 g-1) and Chlorophyll (41.63 SPAD units) were recorded with the application of 50% RDF + Arka Microbial Consortium (AMC) @ 5 kg/ha + Potassium Solubulizing Bacteria (KSB) @ 2.5 kg/ha + Arka vegetable special @ 5 gm/litre in the treatment (T9) and Lowest moisture content (84.46%) with minimum PLW (47.24%) which ultimately increases the shelf life (2.99 days) were also recorded in the same treatment T9.

Keywords: Spinach beet, AMC, KSB, Arka vegetable special

Introduction
Spinach beet (*Beta vulgaris* var. *bengalensis*; 2n=2x=18) is the most popular vegetable crop Grown in India and other parts of the world as leafy vegetable. It belongs to the family Chenopodiaceae. It is also known as Indian spinach, Beet leaf in English and Palak in Hindi and is originated from Indo-Chinese region. (Nath, 1976) [7].
It is rich in vitamins especially vitamin A (97701 IU) and other vitamins like Ascorbic acid (70 mg 100 g-1), Riboflavin, Thiamine. Minerals like Iron and Calcium (380 mg 100 g-1), Folic acid and some amounts of Nicotinic acid, Pyridoxine, Antioxidants as Carotene, Flavones, Indoles and Isothiocyanates, essential amino acids etc. Hence, it is called "Mines of Minerals" (Thamburaj and Singh, 2015) [10].
In this modernization, consumption of chemicals like fertilizers, pesticides, growth regulators *etc.*, have been utilized in the production system. Farmers use huge amount of nitrogenous fertilizers for efficient growth leads to deterioration of quality, shelf-life and presence of chemical residue in leaves which causes harm to consumers.
Biofertilizer is a wide term applied to a diverse category of bio-inoculants such as nitrogen fixers Azotobacter, a nonsymbiotic, free-living, aerobic nitrogen fixing bacteria, can substitute part of inorganic fertilizers. Azotobacter inoculation saves nitrogenous fertilizers by 10-20 per cent (Mohandas, 1999) [6]. Phosphate Solubulizing bacteria (PSB) was reported to play a significant role in solubilizing the inorganic phosphates which are largely unavailable to plants and making it available to crop use (Tilak and Singh, 1994) [11]. Potassium solubilizing bacteria (KSB) can solubilize K-bearing minerals and convert the insoluble K to soluble forms of K available to plant uptake (Etesami *et al.*, 2017) [2].
Arka Microbial Consortium (AMC) is a carrier-based product which contains N Fixing, P and Zn solubilizing and plant growth promoting microbes as a single formulation. Besides, the synergistic effects of the formulated microbes can help in sustainable vegetable production.
Arka vegetable special is a micronutrient formulation contains most of the micronutrients such as Zn, B, Fe, Cu, Mn, Mo and Cl and also contains most of the secondary nutrients such as Ca, Mg, S and K which enhances fruit quality in terms of fruit appearance, fruit keeping quality and taste. It can be mixed with any fungicide or insecticide, recommended for all vegetable crops at different doses.
To maintain and sustain a higher level of soil fertility and crop productivity, by reducing the levels of inorganic nutrients are very important in the crop production system.

Therefore, it has become essential to use untraditional fertilizers as supplements or substitutes for chemical fertilizers. Keeping the facts in view, the study was carried out to examine the best inorganic nutrients and its combination with biofertilizers for better quality and also nutrient availability for crop and soil.

Material and Methods

The experiment was carried out at PG research form College of Horticulture, Rajendranagar, Hyderabad, Telangana during *rabi* season of 2020-2021. The experimental site is situated at the altitude of the 542.3 m above the mean sea level on 17º 191 North latitude and 79º 231 East longitude. The experiment was laid out in randomized block design (RBD) with three replications and ten treatments. Treatments consisted of T1 - 100% RDF @ 100:25:50 kg/ha T2 -75% RDF + Biofertilizers [Azotobacter + Phosphorous Solubulizing Bacteria (PSB) + Potassium Solubulizing Bacteria (KSB)] (Each @ 1.25 kg/ha) T3 - 50% RDF + Biofertilizers [Azotobacter + Phosphorous Solubulizing Bacteria (PSB) + Potassium Solubulizing Bacteria (KSB)] (Each @ 2.5 kg/ha) T4 -25% RDF + Biofertilizers [Azotobacter + Phosphorous Solubulizing Bacteria (PSB) + Potassium Solubulizing Bacteria (KSB)] (Each @ 3.75 kg/ha) T5 -75% RDF + Arka Microbial Consortium (AMC) @ 2.5 kg/ha + Potassium Solubulizing Bacteria (KSB) @ 1.25 kg/ha T6 - 50% RDF + Arka Microbial Consortium (AMC) @ 5 kg/ha + Potassium Solubulizing Bacteria (KSB) @ 2.5 kg/ha T7 - 25% RDF + Arka Microbial Consortium (AMC) @ 7.5 kg/ha + Potassium Solubulizing Bacteria (KSB) @ 3.75 kg/ha T8 - T5 + Arka vegetable special @ 5 gm/litre T9 - T6 + Arka vegetable special @ 5 gm/litre T10 - T7 + Arka vegetable special @ 5 gm/litre.

The field was thoroughly prepared and experimental plots of 2 m x 2 m size were made. Biofertilizers mixed with organic manure were applied as per the rates indicated under the treatments after preparation of layout i.e., FYM, Azotobacter, PSB, KSB and AMC followed by irrigation and fertilizers, full doses of P2O5, K2O were applied respectively through single super phosphate and murate of potash before sowing. While application of nitrogen was made through urea in three equal splits i.e., 50% at the time of sowing and remaining 50% at 30, 45 days after sowing. 3-4 seeds per hill were sown at a spacing of 30×10 cm. Thinning was done at 15 days after sowing and all other cultural and plant protection measures were done as per the recommended package of practices for the healthy crop.

The observations were recorded on quality parameters like Moisture content, Shelf life, carotene content, vitamin-c, SPAD units and Physiological loss in weight. The data collected were analysed statistically by following the analysis of variance (ANOVA) technique (Panse and Sukhatme 1967) [9]. Statistical significance was tested with 'F' value at 5 per cent level of significance and whenever the F value was found significant, Critical difference was worked out at five per cent level of significance.

Results and Discussion

Quality Parameters

Moisture content (%)

Data in respect of moisture content of leaves is presented in Table 1 Highest moisture content was recorded in T1 treatment (100% RDF @ 100:25:50 kg ha-1) (92.54%). Lowest moisture (84.46%) was recorded in treatment T9 (T6 + Arka vegetable special @ 5 g L-1).

However, vegetables with high moisture deteriorate faster. Pertaining to data presented in Table 1 indicated that the treatment receiving 50% RDF through inorganic nutrients and 50% biofertilizers *i.e.*, Arka microbial consortium (AMC) and Potassium solubilizing bacteria (KSB) recorded significantly less moisture content after harvest and in 100% RDF it was high. Lower moisture might be due to higher dry matter accumulation, as a result of increased photosynthetic activity and availability of macro and micro elements. These results are in similar lines with the findings of Karadkhelkar (1985) in spinach.

Shelf life (No. of days)

The data pertaining to shelf life was found significant and is presented in Table 1. The maximum shelf life of spinach was recorded in treatment T9 (T6 + Arka vegetable special @ 5 g L-1) (2.99 days) followed by T8 (T5 + Arka vegetable special @ 5 g L-1) (2.74 days). The minimum (1.20 days) was observed in the T1 treatment (100% RDF @ 100:25:50 kg ha-1).

The increased shelf life due to combined application of inorganic nutrients, biofertilizers and Arka vegetable special micronutrient spray could be due to better nutrient supply helping to maintain equilibrium in metabolism even after harvest. Healthy plant with moderate moisture and less loss of carbohydrates from the produce of this treatment might have helped in increasing the shelf life.

Carotene content (mg 100g-1)

The carotene content of spinach was observed at all the three cutting stages of the crop, and the data is reported as mean in Table 2. Significantly maximum carotene content (10.59 mg 100 g-1) was observed in treatment T9 (T6+ Arka vegetable special @ 5 g L-1) followed by T8 (T5 + Arka vegetable special @ 5 g L-1) (10.19 mg 100 g-1). The minimum carotene content (5.66 mg 100 g-1) was observed in T1 (100% RDF @ 100: 25: 50 kg ha-1).

A mean carotene of 10.59 mg 100 g-1 was obtained and it ranged from 5.66 to 10.59 mg 100 g- 1 among treatments. Application of recommended fertilizer dose had significantly enhanced the carotene content (10.59 mg 100 g- 1). Maurya and Goswami (1985) also reported such highest carotene content with balanced NPK application.

Table 1: Effect of inorganic nutrients and biofertilizers on Moisture content (%) and Shelf life (No. of days) in spinach beet Cv. Pusa Bharati

Treatments	Moisture content (%)	Shelf life (No. of days)
T1 – 100% RDF @ 100:25:50 Kg/ha	92.54	1.20
T2 – 75% RDF + Azotobacter + PSB + KSB (Each @ 1.25 Kg/ha)	88.38	2.51
T3 – 50% RDF + Azotobacter + PSB + KSB (Each @ 2.5 kg/ha)	89.67	2.35
T4 – 25% RDF + Azotobacter + PSB + KSB (Each @ 3.75 kg/ha)	91.95	1.41
T5 – 75% RDF + AMC @ 2.5 kg/ha + KSB 1.25 kg/ha	90.86	2.12
T6 – 50% RDF + AMC @ 5 kg/ha + KSB @ 2.5 kg/ha	91.25	1.86
T7 – 25% RDF + AMC @ 7.5 kg/ha + KSB @ 3.75 kg/ha	91.46	1.50

T8 – T5 + Arka vegetable special @ 5 g/litre	87.39	2.74
T9 – T6 + Arka vegetable special @ 5 g/litre	84.46	2.99
T10 – T7 + Arka vegetable special @ 5 g/litre	91.38	1.63
S.E (m) ±	0.10	0.06
CD at 5%	0.31	0.17

Vitamin-C (mg 100g-1)

Significant differences were observed in respect of Vitamin-C content among different treatment combinations of inorganic nutrients and biofertilizers and data mean values are presented in Table 2.

The maximum Vitamin-C content in palak leaves (65.70 mg 100g-1) was recorded in treatment T9 (T6 + Arka vegetable special @ 5 g L-1) followed by treatment T8 (T5 + Arka vegetable special @ 5 g L-1) (64.60 mg 100g-1). The lowest Vitamin-C content (43.18 mg 100g-1) was observed in the treatment T1 (100% RDF @ 100:25:50 kg ha-1).

The ascorbic acid (Vitamin-C) content in spinach leaves ranged from 43.18 to 65.70 mg 100g-1. The highest ascorbic acid content was recorded with the treatment 50% RDF through inorganic fertilizers with integration of 50% biofertilizers could be enhanced the growth promoting substances which accelerates the physiological process like synthesis of carbohydrates. The results unison with the findings of Kalyani *et al*. (1996) [3] in cauliflower, Balakrishnan (1988) [1] in chillies.

SPAD units

The chlorophyll content of spinach was measured with a spadmeter at all the three cutting stages of the crop, and the data is reported as mean spadmeter readings in Table 2.

The chlorophyll content was the highest (41.63 SPAD units) when the crop received all the three major nutrients in treatment T9 (T6 + Arka vegetable special @ 5 g L-1) followed by T8 (T5 + Arka vegetable special @ 5 g L-1) (40.41 SPAD units). The lowest value recorded in treatment T1 (100% RDF @ 100:25:50 kg ha-1) (29.25 SPAD units).

Higher chlorophyll content in treatment T9 might be due to the application of 50% RDF where maximum nitrogen is available and Arka microbial consortium contains N fixing, P and Zn solubilizing microbes' involvement in protein synthesis could have resulted more chlorophyll synthesis in spinach beet. These results are in agreement with the findings of Paithankar and Gore (2018) [8].

Physiological loss in weight (%)

The data regarding physiological loss in weight of spinach influenced due to different treatments of inorganic and biofertilizers presented in Table 3.

The data clearly revealed that there was increase in weight loss of spinach as per the storage period. The minimum physiological loss in weight was recorded in treatment T9 (T6 + Arka vegetable special @ 5 g L-1) (47.24%) followed by T8 (T5 + Arka vegetable special @ 5 g L- 1) (47.32%). The maximum physiological loss in weight (55.31%) was recorded in treatment.

Table 2: Effect of inorganic nutrients and biofertilizers on Carotene content (mg 100g-1), Vitamin-C (mg 100g-1) and SPAD units in spinach beet Cv. Pusa Bharati

Treatments	Carotene content (mg 100g-1)	Vitamin-C (mg 100g-1)	SPAD units
T1 – 100% RDF @ 100:25:50 Kg/ha	5.66	43.18	29.25
T2 – 75% RDF + Azotobacter + PSB + KSB (Each @ 1.25 Kg/ha)	9.52	62.56	39.05
T3 – 50% RDF + Azotobacter + PSB + KSB (Each @ 2.5 kg/ha)	9.32	56.80	37.94
T4 – 25% RDF + Azotobacter + PSB + KSB (Each @ 3.75 kg/ha)	8.25	51.63	34.13
T5 – 75% RDF + AMC @ 2.5 kg/ha + KSB 1.25 kg/ha	8.43	52.15	35.31
T6 – 50% RDF + AMC @ 5 kg/ha + KSB @ 2.5 kg/ha	8.97	54.35	36.78
T7 – 25% RDF + AMC @ 7.5 kg/ha + KSB @ 3.75 kg/ha	7.67	48.88	32.97
T8 – T5 + Arka vegetable special @ 5 g/litre	10.19	64.60	40.41
T9 – T6 + Arka vegetable special @ 5 g/litre	10.59	65.70	41.63
T10 – T7 + Arka vegetable special @ 5 g/litre	6.46	45.98	31.36
S.E (m) ±	0.117	0.349	0.326
CD at 5%	0.342	1.03	0.968

T1 (100% RDF @ 100:25:50 kg ha-1).

The application of biofertilizers probably reduced the respiration rate, which in turn resulted in higher shelf life and reduction in PLW. The higher moisture content in inorganic spinach leads to more percentage of respiration, rotting and decaying due to microbial activity and ultimately decrease its shelf life. Higher physiological loss in weight (%) recorded in treatment T1 may be due to loss of water in the fresh produce can cause reduction in turbidity, loss of nutritional quality and undesirable changes in colour. The weight loss is mainly caused by water transpiration and respiration.

Table 3: Effect of inorganic nutrients and biofertilizers on physiological loss in weight (%) in spinach beet Cv.Pusa Bharati.

Treatments	Physiological loss in weight (%)			
	Day-1	Day-2	Day-3	Mean
T1 – 100% RDF @ 100:25:50 Kg/ha	26.57	66.45	87.65	55.31
T2 – 75% RDF + Azotobacter + PSB + KSB (Each @ 1.25 Kg/ha)	19.97	44.46	74.47	48.48
T3 – 50% RDF + Azotobacter + PSB + KSB (Each @ 2.5 kg/ha)	20.01	47.35	75.60	49.17
T4 – 25% RDF + Azotobacter + PSB + KSB (Each @ 3.75 kg/ha)	26.52	63.24	81.52	55.09
T5 – 75% RDF + AMC @ 2.5 kg/ha + KSB 1.25 kg/ha	21.11	51.07	76.52	49.51
T6 – 50% RDF + AMC @ 5 kg/ha + KSB @ 2.5 kg/ha	22.30	53.00	77.29	49.75

T7 – 25% RDF + AMC @ 7.5 kg/ha + KSB @ 3.75 kg/ha	25.88	56.96	80.13	54.45
T8 – T5 + Arka vegetable special @ 5 g/litre	18.06	42.79	73.04	47.32
T9 – T6 + Arka vegetable special @ 5 g/litre	17.66	40.19	69.43	47.24
T10 – T7 + Arka vegetable special @ 5 g/litre	24.25	56.20	79.55	50.20
S.E (m) ±	0.182	0.182	0.182	-
CD at 5%	0.542	0.542	0.542	-

Conclusion
In the present investigation supplementation of FYM, Azotobacter, PSB, KSB and AMC along with reduced level of inorganic nutrients like urea, SSP and MOP improved quality parameters of spinach beet it is recommended to make integrated use of inorganic 50% RDF, 50% organic (AMC @ 5 kg/ha + KSB @ 2.5 kg/ha) along with micronutrient spray i.e., Arka vegetable special @ 5 g/litre at 15, 30 and 45 days after sowing for spinach beet cultivation.

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