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Influence of agronomic management practices on the leaf yield and nutrient uptake in palak (*Beta vulgaris* (L) var. *bengalensis*)

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Abstract

The field experiment on the effect of agronomic management practices: planting geometry, nutrient management and number of harvests, on leaf yield and nutrient uptake in palak (*Beta vulgaris* (L) var. *bengalensis*) was conducted at College of Agriculture, Vellayani in 2 x 2 x 3 factorial design with three replications. Significant variations were recorded in yields with the individual effects, but the interaction effects were found to be non significant. The superior leaf yields recorded were in the range of 102.41 to 107.22 g per plant and the highest P and K uptake with the combination of wider spacing, inorganic nutrition and higher number of harvests, the values being 0.119 and 1.46 g per plant. Based on the results, a spacing of 30 cm x10 cm and inorganic nutrient sources to provide nutrients @ 80:40:80 kg NPK ha^{-1} and six harvests can be recommended in palak.

Keywords: Palak, harvest, leaf yield, spacing, uptake

Introduction

Leafy vegetables are of paramount importance in balanced diet being rich sources of protein, vitamin C, beta carotene, vitamins from B group and minerals. The important leafy vegetables cultivated in the country include amaranthus, cabbage, palak, broccoli, kale, parsley, lettuce, coriander and fenugreek. Of these, palak or Indian spinach (*Beta vulgaris* (L) var. *bengalensis*) has assumed importance in the south Indian state, Kerala, in the recent years. The suitability for cultivation was evaluated [1] and polyhouse cultivation was found to be ideal for year round cultivation of the crop. Management practices are crucial for a crop to realise its full yield potential. Research literature have shown the different agronomic practices like sowing time [2, 3] spacing [4], nutrient management [5], biofertilizers [6] irrigation [7], and cutting frequency [8] play key roles in palak cultivation for higher yields. Being a new introduction in Kerala, production technologies have not been standardised and hence an attempt was made to assess the influence of the management practices: spacing, nutrient management and number of harvests on the yield and nutrient uptake in palak.

Materials and Methods

The experiment was conducted at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala in the naturally ventilated polyhouse established in the Crop museum attached to the Department of Agronomy. The polyhouse had its sides open and roof cladding of 200 micron UV stabilized polythene sheet. The soil was acidic, medium in organic carbon (C) and available potassium (K), low in available nitrogen (N) and high in available P. The experiment was laid out in randomized block design with 12 treatments in three replications during October 2019 to January 2020. The variety used was All Green. The treatments comprised of two spacings (s_1: 20 cm x 10 cm; s_2: 30 cm x 10 cm), two nutrient management practices (n_1: inorganic sources; n_2: organic sources) and three number of harvests (h_1: four harvests; h_2: five harvests; h_3: six harvests). Seeds were directly sown in the field after treatment with *Pseudomonas fluorescens* @ 20 g per kg seed. The field was uniformly manured with farm yard manure (FYM) @ 10 t ha^{-1}. A nutrient dose of 80: 40: 80 kg NPK ha^{-1} [1] was given using different sources as per treatments fixed. One fourth N and K, full P were given as basal, remaining N and K, in equal splits as top dressing, 20 days after sowing (DAS) and after the first and second harvests (40 and 60 DAS).

The organic sources used in the study were vermicompost, rock phosphate, and wood ash along with biofertilizer arbscular mycorrhizhal fungi (AMF) and the inorganic sources, urea, rock phosphate and muriate of potash. The quantities required were computed based on the nutrient contents of the nutrient sources (Table 1).

Table 1: Nutrient content in the sources used (%)

Source	N	P_2O_5	K_2O
Vermicompost	1.28	0.48	0.54
Rock phosphate	-	20.0	-
Wood ash	-	-	6.03
Urea	46.0	-	-
Muriate of potash	-	-	60.0

Five representative plants were randomly selected from the net plot area avoiding the border rows and labeled as observation plants. The harvest was taken 40, 60 and 70 DAS uniformly in all treatments, and thereafter, at 80, 95 and 105 DAS as per the treatments fixed. In h_1, the final harvest was done 80 DAS, in h_2, 95 DAS and in h_3, 105 DAS. The fresh weight of the leaves at each harvest in the observation plants were recorded and summed to get the total leaf yield per plant. For computation of dry matter production (DMP), the observation plants at final harvest were uprooted, dried under shade and then in a hot air oven at 70 ± 5°C to a constant weight, and weighed to record the total dry matter production in g plant[1]. The dried samples were finely ground and digested for estimation of NPK content. N content was estimated by the modified micro kjeldhal method [9], P content of diacid extract of samples determined colorimetrically using vanadomolybdo phosphoric yellow colour method [9] and K using flame photometry method [9]. The nutrient contents were expressed in percentage and nutrient uptake by the crop was calculated using the formula,

Nutrient uptake (g $plant^{-1}$) = Nutrient content (%) x Total DMP (g $plant^{-1}$).

The data were analysed statistically using Analysis of Variance techniques (ANOVA) for 2 x 2 x 3 Factorial Randomised Block Design and the significance tested by applying 'F' test [10]. Wherever F test found to be significant, the critical difference (CD) values were computed for comparison.

Results and Discussion

Yield and Dry matter production

The variations in in palak leaf yield, DMP and nutrient uptake due to the treatments are presented in Tables 2, 3 and 4.

The per plant leaf yields varied significantly with spacing, nutrient management and number of harvests. Significantly superior yields were recorded with wider spacing (103.07 g), inorganic nutrient sources (102.41g) and six harvests (107.22 g). The first and second order interactions did not show any significant variation in the per plant yield. Similarly DMP also showed significant variations due to the main effects but the interaction effects were non-significant. Wider spacing (s_2) resulted in the maximum DMP of 34.54 g $plant^{-1}$ which was significantly superior to s_1 (32.32 g $plant^{-1}$). Inorganic nutrient management (n_1) produced significantly superior DMP (34.36 g $plant^{-1}$) compared to the plants given organic nutrient sources (n_2). The highest number of harvests taken recorded the highest DMP (h_3- 35.76 g $plant^{-1}$) followed by five harvests at par with four harvests (32.7 and 31.85 g $plant^{-1}$ respectively) in line with the yields recorded.

Spacing ensures an equal chance for each plant to grow, thus plant density and spatial arrangement determines the competitive relationship in a plant community [11]. A high plant density hinders proper growth and development of individual plant and reduces yield, on the other hand it results in high yield per unit area due to increased plant population [12]. Under wider spacing, inter plant competition for growth factors will be reduced thus favouring growth and enabling the plants to express their genetic potential. Better canopy development and radiation interception favour increased assimilation of photosynthates ultimately resulting in high yield and DMP. Similar results in palak were reported by [13].

Leafy greens, palak in particular, is highly fertilizer responsive [14], and hence demands large quantity of nutrients especially N. Nitrogen promotes growth, canopy development, radiation interception and photosynthates assimilation as it is the essential component of structural, metabolic and genetic constituents of cells [15]. Vegetative growth is promoted by N application and hence is critical in leafy vegetables [16], as stem and leaves constitute the economic produce. Frequent harvests necessitate early and rapid re-growth and new flushes which calls for N fertilization as top dressing. Nevertheless, the nutrient requirement of a crop is not confined to N alone. Irrespective of the crop species, balanced fertilization requires prime attention. In spinach, balanced NPK nutrition increased yield and DMP [17, 18]. The importance of P and K in palak has been elucidated by several authors [1, 19].

Increased growth and yield in palak with organic manure and RDF application was reported by [20]. A basal dose of FYM @ 10 t $ha^{-1}$was applied uniformly in all treatments and this would have taken care of the soil physical and biological properties that favoured growth in the inorganic nutrition. The chemical fertilizers could cater the immediate requirements of N, P and K in the early stages and also the re-growth after the repeated cuttings. Rapid availability of N through chemical fertilizers during active growth stage increases vegetative growth and ultimately results in higher yield and DMP [21]. The findings of [13, 22] in palak and [23, 24] in amaranthus are in confirmation with the present result of increased green yield with inorganic nutrition.

In the case of number of harvests, yields increased with the number of cuttings. More number of harvests contributed significantly to the total yields realized per plant owing to the additional number of leaves harvested with each picking. The capacity of palak to regenerate and develop new flushes with successive harvests would be the plausible reason for increased yield [25]. The observations are in congruence with the findings of [19, 26].

Nutrient uptake

The N and P uptake were significantly influenced by all the three main factors, while K uptake was significant for nutrient management and number of harvests (Table 2). The significantly highest N and P uptake (1.48 and 0.101 g $plant^{-1}$) were recorded in the wider spaced plants (s_2). Among nutrient sources, the highest N, P and K uptake (1.45, 0.105 and 1.40 g $plant^{-1}$) were computed in plants manured with inorganic nutrient sources (n_1). The more the number of harvests, more was the nutrient uptake recorded. The highest values (1.42, 0.102 and 1.37 g $plant^{-1}$) were noted in h_3 and the lowest in h_1. S x N and N x H interactions registered significant variations in N uptake and S x H and N x H for K uptake (Table 3). The S x N x H interaction was significant for P and K uptake only. In all the interactions, it was the combination involving the wider spacing, inorganic nutrition and higher number of harvests recorded the highest nutrient uptake (Table 3).

Nutrient uptake is an indication of nutrient use efficiency by the crop and is dependent on the nutrient content and DMP of the crop. The better uptake of N and P recorded with the wider spacing 30 cm x 10 cm (s_2) may be attributed to the higher yield and hence dry matter accumulation consequent to better nutrient absorption with wider spacing, in response to lower density stress as compared to closer spacing. Higher nutrient uptake under wider spacing was due to the superior growth and yield attributes that were curtailed under closer spacing due to higher inter plant competition [27]. Increased N uptake under wider spacing was reported by [28] in coriander. Generally when the N uptake is higher, the plants show a tendency to accumulate more P and this was observed in this study also. A balanced NPK absorption is important for proper growth and satisfactory yields, both in terms of quantity and quality, which is possible with balanced fertilisation [29].

The nutrient uptake (N, P and K) found superior for plants fertilized with inorganic nutrient sources can be endorsed to the additive influence of increased dry matter accumulation and nutrient content, in response to enhanced nutrient availability from chemical fertilizers [30] in amaranthus and [31] in spinach also reported increased nutrient uptake with the application of chemical fertilizers.

With respect to the of number of harvests, nutrient (N, P and K) uptake were significantly the highest for plants with six harvests which is explained by the increased dry matter production owing to the more number of harvests done. This accords the reports of [6, 32] in spinach.

The interaction effects correspond to the individual effects of the factors contributing to the higher yields, DMP and nutrient content *i.e.*, in response to enhanced growth with wider spacing, readily available nutrients and more number of harvests. The results of the study reveal that a spacing of 30 cm x10 cm, inorganic sources of nutrients, urea, rajphos and muriate of potash to supply the NPK dose of 80:40:80 kg ha^{-1} and six harvests can be recommended for higher yields and nutrient uptake in palak under rain shelter conditions.

Table 2: Effect of spacing, nutrient management and number of harvests on leaf yield, DMP and NPK uptake, g plant^{-1}

Treatments	Leaf yield	DMP	Nutrient uptake		
			N	P	K
Spacing (S)					
s_1 (20 cm x10 cm)	96.93	32.32	1.22	0.093	1.32
s_2 (30 cm x10 cm)	103.07	34.54	1.48	0.101	1.31
SEm (±)	1.23	0.44	0.02	0.002	0.02
CD (0.05)	3.612	1.283	0.059	0.005	NS
Nutrient management (N)					
n_1 (inorganic)	102.41	34.36	1.45	0.105	1.40
n_2 (organic)	97.58	32.51	1.25	0.089	1.23
SEm (±)	1.23	0.44	0.02	0.002	0.02
CD (0.05)	3.612	1.283	0.059	0.005	0.053
Number of harvests (H)					
h_1 (four)	93.99	31.85	1.31	0.095	1.22
h_2 (five)	98.79	32.70	1.33	0.095	1.35
h_3 (six)	107.22	35.76	1.42	0.102	1.37
SEm (±)	1.51	0.54	0.02	0.002	0.02
CD (0.05)	4.424	1.572	0.072	0.007	0.064

DMP – Dry matter production

Table 3: Interaction effects of spacing, nutrient management and number of harvests on yield, DMP and NPK uptake, g plant^{-1}

Interactions	Leaf yield	DMP	Nutrient uptake		
			N	P	K
S x N interaction					
s_1n_1	100.39	33.44	1.39	0.100	1.40
s_1n_2	93.47	31.20	1.06	0.087	1.24
s_2n_1	104.44	35.27	1.51	0.110	1.40
s_2n_2	101.69	33.82	1.45	0.092	1.22
SEm (±)	1.741	0.62	0.03	0.003	0.03
CD (0.05)	NS	NS	0.072	NS	NS
S x H interaction					
s_1h_1	91.96	30.87	1.19	0.094	1.20
s_1h_2	95.95	31.69	1.19	0.089	1.31
s_1h_3	102.89	34.40	1.28	0.096	1.45
s_2h_1	96.02	32.82	1.42	0.095	1.25
s_2h_2	102.63	33.70	1.47	0.100	1.38
s_2h_3	111.56	37.12	1.56	0.108	1.30
SEm (±)	2.13	0.76	0.04	0.003	0.03
CD (0.05)	NS	NS	NS	NS	0.091
N x H interaction					
n_1h_1	94.64	32.05	1.35	0.099	1.38
n_1h_2	102.84	33.83	1.43	0.105	1.35
n_1h_3	109.77	37.18	1.57	0.111	1.47
n_2h_1	93.33	31.64	1.26	0.091	1.07
n_2h_2	94.74	31.56	1.23	0.084	1.34
n_2h_3	104.68	34.33	1.28	0.094	1.28
SEm (±)	2.13	0.76	0.04	0.003	0.03
CD (0.05)	NS	NS	0.101	NS	0.091

DMP – Dry matter production

Table 4: Effect of S x N x H interaction on yield, DMP and NPK uptake, g plant^{-1}

Treatment combinations	Leaf yield	DMP	Nutrient uptake		
			N	P	K
$s_1n_1h_1$	93.89	31.74	1.32	0.102	1.37
$s_1n_1h_2$	100.48	33.01	1.33	0.092	1.35
$s_1n_1h_3$	106.80	35.58	1.51	0.106	1.49
$s_1n_2h_1$	90.02	29.99	1.06	0.087	1.04
$s_1n_2h_2$	91.42	30.38	1.05	0.087	1.27
$s_1n_2h_3$	98.98	33.23	1.06	0.087	1.41
$s_2n_1h_1$	95.39	32.36	1.38	0.096	1.38
$s_2n_1h_2$	105.20	34.66	1.52	0.119	1.35
$s_2n_1h_3$	112.73	38.79	1.63	0.116	1.46
$s_2n_2h_1$	96.64	33.28	1.45	0.094	1.11
$s_2n_2h_2$	98.05	32.74	1.41	0.081	1.42
$s_2n_2h_3$	110.39	34.44	1.50	0.100	1.14
SEm (±)	3.016	1.071	0.05	0.005	0.04
CD (0.05)	NS	NS	NS	0.013	0.129

DMP – Dry matter production

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