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Effect of varieties and nutrient levels on growth, quality and nutrient uptake of palak (*Beta vulgaris* var. Bengalensis)

Ilal Khedkar, RK Sharma, SS Kushwah and Roshan Gallani

Abstract
The present investigation entitled "Effect of varieties and nutrient levels on growth, quality and nutrient uptake of palak (*Beta vulgaris* var. bengalensis)" was conducted at Vegetable Research Field, College of Horticulture, Mandsaur (M.P.) during *Rabi* season, 2019-20 with two varieties V_1 (Pusa Bharati), V_2 (All Green) and 6 different nutrient levels (N_1- 00:00:00 NPK kg/ha, N_2- 40:30:20 NPK kg/ha, N_3- 60:40:30 NPK kg/ha, N_4- 80:50:40 NPK kg/ha, N_5- 100:60:50 NPK kg/ha and N_6 - 120:70:60 NPK kg/ha) with three replications. The experiment was laid out in a factorial randomized block design. Data from experiment revealed that among varieties V_1 (Pusa Bharati) found better for growth, quality and nutrient uptake of palak and recorded maximum fresh weight of plant (21.96 g, 22.80 g and 24.11 g) and maximum dry weight of plant (3.68 g, 3.89 g and 3.99 g) at 1st, 2nd and 3rd cuttings, respectively, maximum TSS content (7.70 °Brix), maximum iron content of leaf (13.36 mg/100 g) and maximum N (2.919%), P (0.703%) and K (3.208%) content in plant at harvest. While, maximum leaf moisture content i.e. 84.48%, 84.78% and 84.90%, was recorded at 1st, 2nd and 3rd cuttings, respectively, maximum nitrogen (209.40 kg/ha), phosphorus content in soil (16.34 kg/ha) and potassium (412.36 kg/ha) content in soil after harvest recorded in variety V_2 (All Green). Among nutrient levels, N_6 (120:70:60 NPK kg/ha) was recorded maximum fresh weight of plant (24.67 g, 24.68 g and 27.06 g), maximum dry weight of plant (4.70 g, 5.11 g and 5.20 g) at 1st, 2nd and 3rd cuttings, respectively, maximum TSS content (8.16 °Brix), maximum iron content of leaf (14.90 mg/100 g) and maximum N (3.122%), P (0.862%) and K (3.743%) content in plant at harvest. The maximum nitrogen (216.05 kg/ha), phosphorus content in soil (20.23 kg/ha) and potassium (418.42 kg/ha) content in soil after harvest was found with N_6 (120:70:60 NPK kg/ha).

Keywords: All green, growth, NPK, TSS, nutrient uptake, palak, Pusa Bharati, iron content

Introduction
Palak, scientifically known as *Beta Vulgaris*, is a leafy green vegetable renowned for its nutritional value and culinary versatility. This versatile leafy vegetable is rich in vitamins, minerals, antioxidants, and dietary fiber, making it a vital component of a balanced diet. The demand for palak has been steadily rising due to its perceived health benefits and its incorporation into various cuisines worldwide. However, to meet this escalating demand and ensure a consistent supply of high-quality palak, it is imperative to optimize the cultivation practices, particularly in terms of nutrient management (Bose *et al*., 2003) [5].

On an average it's leaves contain moisture 86.49%, fiber 0.7 g, protein 3.4 g, minerals 2.2 g, carbohydrates 6.5 g, riboflavin 0.5 g, calcium 380 mg, iron 16.2 mg, thiamin 0.26 g, Vitamin-A 9770 IU, Vitamin-C 70 mg/100 g of edible portion (Vishnu Swarup, 2014) [19].

Fertilizer management has considerable practical importance for obtaining high yield with good quality. Nitrogen (N), Phosphorous (P) and Potassium (K) are essential major elements for all life processes in plants. They are important components (N and P) for different essential organic compounds such as nucleic acids, amino acids, proteins, enzymes, vitamins and biochemical process that comprise the several stages of the plant growth and development (El-Saady, 2016) [6]. Potassium also plays a vital role in plant-water relations regulating many plant metabolic processes through its important role in the activation of necessary enzyme reactions and amelioration of quality parameters through speeding of the translocation assimilates and other solutes from plant leaves to edible plant parts (El-Saady, 2016) [6]. Keeping the above facts in view, the present investigation was undertaken to ascertain the optimum nutrient level for production of palak.

Material and Methods

The present experiment was carried out during Rabi season, 2019-20 at Research Field, Department of Vegetable Science, College of Horticulture, Mandsaur (MP) to evaluate the performance of varieties and nutrient levels on growth, quality and nutrient uptake. Mandsaur is situated in western part of Madhya Pradesh, between latitude of 23° 45' to 24° 13' North, longitude of 74°44' to 75°18' East and at an altitude of 435.20 m above mean sea level. This region lies under Malwa Plateau, the 10th agro climatic zone of the state. The topography of the experimental field was plain with good irrigation facilities. The experiment was layout in the Factorial Randomized Block Design (FRBD) with three replications. The treatments consisted of two varieties (Pusa Bharati and All Green) and six different nutrient levels (N_1- 00:00:00 NPK kg/ha, N_2- 40:30:20 NPK kg/ha, N_3- 60:40:30 NPK kg/ha, N_4- 80:50:40 NPK kg/ha, N_5- 100:60:50 NPK kg/ha and N_6- 120:70:60 NPK kg/ha). Entire quantity of P and K and half dose of N as per treatment was applied in the form of DAP, MOP and Urea, respectively before transplanting at the time of field preparation. Remaining dose of N was given twenty five days after sowing. Optimum soil moisture was maintained in the field throughout the investigation by using flood irrigation system. The soil samples were collected before and after the experimentation and analyzed. Five plants were randomly selected from each plot and tagged. The data obtained on various observations for each treatment were subject to "Analysis of variance" as recommended by Panse and Sukhatme (1984) [13].

Results and Discussion

Growth Parameters

Growth of the palak was studied with respect to fresh weight of plant, dry weight of plant and leaf moisture content was observed at 1st, 2nd and 3rd leaf cutting of palak.

The results pertaining to fresh weight of plant as affected by varieties and nutrient levels are presented in Table 1. Fresh weight of plant was revealed significant effect of varieties and nutrient levels. The findings revealed significant effect of varieties on fresh weight of plant at all the growth stages studied. Maximum fresh weight of plant i.e. 21.96, 22.80 and 24.11 g was found with variety V_1 (Pusa Bharati) and minimum fresh weight of plant i.e. 20.15, 20.58 and 21.90 g was recorded in case of variety V_2 (All Green) at 1st, 2nd and 3rd cutting, respectively. The variation among varieties for fresh weight of plant may be attributed to their genetic architecture. The results are in conformity with findings of Sharma *et al*. (2001) [15] and Hasan *et al*. (2016) [10].

It is evident from the data that nutrient levels had exerted significant influence on fresh weight of plant. Nutrient level N6 (120:70:60 NPK kg/ha) recorded maximum fresh weight of plant i.e. 24.67, 24.68 and 27.06 g at 1st, 2nd and 3rd cutting, respectively. Nutrient levels N_1 (00:00:00 NPK kg/ha) was recorded minimum fresh weight i.e. 17.27 g, 18.40 g and 19.40 g at 1st, 2nd and 3rd cuttings, respectively. The increases in vegetative growth traits resulting from the fertilizer treatment may be due to the effective impacts of NPK components in stimulating different physiological and biochemical activities within plant cells including the processes of photosynthesis and biosynthesis of important organic components that are needed for promoting meristematic activity to generate more cells, tissues and organs bringing high plant growth (El-Saady, 2016) [6]. These findings are in line with the result of Aguoru *et al*. (2014) [1], Solangi *et al*. (2015) [18], Fouda (2016) [7] and Shormin and Kibria (2018) [16].

The results obtained on dry weight of plant as significantly influenced by varieties and nutrient levels at all the growth stage studies and it is presented in Table 1. The results indicated significant influence of varieties on dry weight of plant at all the stages of study. Variety V_1 (Pusa Bharati) found maximum dry weight of plant i.e. 3.68, 3.89 and 3.99 g at 1st, 2nd and 3rd cutting, respectively and minimum dry weight of plant i.e. 3.18, 3.17 and 3.34 g was recorded in variety V_2 (All Green). The results are in conformity with the findings of Sharma *et al*. (2001) [15] and Masufi *et al*. (2020) [11].

Dry weight of plant was significantly influenced by nutrient levels in palak. Maximum dry weight of plant i.e. 4.70, 5.11 and 5.20 g was observed in nutrient level N_6 (120:70:60 NPK kg/ha) and, whereas minimum dry weight of plant i.e. 2.36, 2.55 and 2.76 g was found in nutrient levels N_1 (00:00:00 NPK kg/ha). Similar results were reported by Gairola *et al*. (2009) [8], Aisha *et al*. (2013) [2], Hafez *et al*. (2015) [9] and Shormin and Kibria (2018) [16].

The data gathered on leaf moisture content (%) showed significant influence of varieties as well as nutrient levels are presented in Table 1. Combined effect of varieties and nutrient levels showed non significant effect on leaf moisture content (%) in palak. A perusal of data indicates significant influence of varieties on leaf moisture content (%). Among varieties, the minimum leaf moisture content i.e. 83.44, 83.09 and 83.50% at 1st, 2nd and 3rd cutting, respectively was noted in variety V_1 (Pusa Bharati) and maximum leaf moisture content i.e. 84.48, 84.78 and 84.90% was recorded in variety V_2 (All Green) at 1st, 2nd and 3rd cuttings, respectively. Similar result was showed by Beiquan Mou (2008) [3]. Nutrient levels had exerted significant effect on leaf moisture content. Maximum leaf moisture content i.e. 86.42, 86.14 and 85.80% at 1st, 2nd and 3rd cutting, respectively was recorded under nutrient levels N_1 (00:00:00 NPK kg/ha and it was at par with treatment N_2 (40:30:20 NPK kg/ha) and closely followed by treatment N_3 (60:40:30 NPK kg/ha), whereas the minimum leaf moisture content i.e. 80.97, 79.12 and 80.73% was found in nutrient levels N_6 (120:70:60 NPK kg/ha) at 1st, 2nd and 3rd cutting, respectively. Similar findings were reported by Bharad *et al*. (2013) [4] and Singh *et al*. (2015) [17].

Quality Parameters

Perusal of data given is Table 2 revealed that TSS was affected significantly with varieties and nutrient levels. While, combined effect of varieties and nutrient levels showed non significant influence on TSS content (^{0}Brix) of palak. Among varieties, maximum TSS content (7.70°Brix) was noted in variety V_1 (Pusa Bharati) and minimum TSS content (7.10°Brix) recorded with variety V_2 (All Green). A perusal of data indicates that nutrient levels had exerted significant effect on TSS (°Brix) content in palak. Maximum TSS content (8.16^{0}Brix) was recorded with nutrient levels N_6 (120:70:60 NPK kg/ha) and it was at par with treatment N_5 (100:60:50 NPK kg/ha) and closely followed by treatment N_4 (80:50:40 NPK kg/ha), whereas minimum TSS content (5.96^{0}Brix) was observed under nutrient levels N_1 (00:00:00 NPK kg/ha). Similar results were also reported by El-Saady *et al*. (2016) [6]. The results on iron content of leaves as significantly

influenced by varieties and nutrient levels and presented in Table 2. Iron content of leaves was estimated after harvesting. Combined effect of varieties and nutrient levels showed non significant influence on iron content of leaf (mg/100 g) of palak. Among the varieties, maximum iron content of leaf (13.36 mg/100 g) was found in variety V_1 (Pusa Bharati) and minimum iron content of leaf (11.53 mg/100 g) was recorded in variety V_2 (All Green). Similar results were also reported by Olaniyi *et al*. (2008) [12] and Masufi *et al*. (2020) [11].

Application of nutrients exhibited significant effect on iron content of leaves. Maximum iron content of leaf (14.90 mg/100 g) was recorded in nutrient levels N_6 (120:70:60 NPK kg/ha) and it was at par with N_5 (100:60:50 NPK kg/ha), whereas minimum iron content of leaf (10.71mg/100 g) was observed in nutrient levels N_1 (00:00:00 NPK kg/ha). Potassium application increases the uptake of such nutrients as Fe^{2+} that are known to be associated with the synthesis of chlorophyll (Gairola *et al*., 2009) [8]. Similar results were also reported by Sajirani *et al*. (2012) [14].

NPK Content in plant at harvesting (%)

The findings of the present experiment (Table 2) denoted significant effect of nutrient levels on NPK content in plant. Effect of varieties and interaction effect of varieties and nutrient levels were found non-significant on nitrogen content in plant at harvesting stage.

Application of nutrient levels exhibited positive effect on nitrogen content in plant. Maximum nitrogen content (3.122%) in plant was recorded with nutrient levels N_6 (120:70:60 NPK kg/ha) which was significantly superior over other nutrient levels. N_6 was followed by $N_5>N_4>N_3>N_2$ with a nitrogen content of 3.072, 2.928, 2.828 and 2.700%, respectively, whereas the minimum nitrogen content (2.630%) in plant was observed under nutrient levels N_1 (00:00:00 NPK kg/ha).

The findings showed that phosphorus in the plant increased with increasing nutrient levels. It is evident from the data that among in nutrient levels, the maximum phosphorus content (0.862%) in plant was noted in nutrient levels N_6 (120:70:60 NPK kg/ha) which was significantly superior over all other nutrient levels. It was followed by $N_5>N_4>N_3>N_2$ phosphorus content of 0.813, 0.738, 0.652 and 0.577%, respectively at harvesting stage. Minimum phosphorus content (0.517%) in plant was observed under nutrient levels N_1 (00:00:00 NPK kg/ha).

Application of nutrient levels exhibited positive effect on potassium content in plant after harvesting. Highest potassium content (3.743%) in plant was recorded in nutrient levels N_6 (120:70:60 NPK kg/ha) which was significantly superior over other nutrient levels. N_6 was followed by $N_5>N_4>N_3>N_2$ with a potassium content of 3.455, 3.198, 3.070 and 2.828%, respectively, whereas the lowest potassium content (2.692%) in plant was found in nutrient levels N_1 (00:00:00 NPK kg/ha).

Balanced quantity of NPK under N_6 treatment might have enhanced the NPK absorption thereby higher content in plant. The increase in N, P, K concentrations in plant with increasing rate of NPK fertilizer may be owed to the availability of N, P, K nutrients for plant and improving root growth, hence increasing the absorption of area of root (Fouda, 2016) [7]. Similar results were also reported by Sajirani *et al*. (2012) [14] and El-Saady (2016) [6] who showed that NPK concentration in plant increasing with increasing of level of NPK fertilizers.

Available NPK content in soil after harvest (kg/ha)

The findings of the present experiment (Table 2) denoted significant effect of nutrient levels on nitrogen content in soil after harvest. Combined effect of varieties and nutrient levels were found non-significant on nitrogen content in soil after harvest. Among the varieties, minimum available nitrogen in soil (202.25 kg/ha) was determined with variety V_1 (Pusa Bharati) and maximum nitrogen content in soil (209.40 kg/ha) after harvest was recorded in case of variety V_2 (All Green). Application of nutrients exhibited positive effect on nitrogen in soil after harvesting. Maximum available nitrogen content in soil (216.05 kg/ha) was recorded with nutrient levels N_6 (120:70:60 NPK kg/ha) and it was at par with N_5 (100:60:50 NPK kg/ha) and closely followed by treatment N_4 (80:50:40 kg/ha), whereas the minimum available nitrogen content in soil (193.26 kg/ha) was determined under nutrient levels N_1 (00:00:00 NPK kg/ha).

The investigations revealed significant effect of varieties and nutrient levels on phosphorus content in soil showed in Table 2. Interaction effect of varieties and nutrient levels were found non-significant on phosphorus content in soil after harvesting. Among the varieties, minimum available phosphorus content in soil (14.36 kg/ha) was noted with variety V_1 (Pusa Bharati) and maximum available phosphorus content in soil (16.34 kg/ha) was observed with variety V_2 (All Green). Among the nutrient levels, maximum available phosphorus content in soil (20.23 kg/ha) was noted with nutrient levels N_6 (120:70:60 NPK kg/ha) and It was at par with N_5 (100:60:50 NPK kg/ha) and closely followed by N_4 (80:50:40 NPK kg/ha), whereas the minimum available phosphorus content in soil (11.93 kg/ha)was observed under nutrient levels N_1 (00:00:00 NPK kg/ha).

Data presented in Table 2 showed that significant effect of varieties and nutrient levels on potassium content in soil after harvesting. Combined effect of varieties and nutrient levels had non significant influence on potassium content in soil after harvesting of palak. Available potassium content in soil was affected significantly with varieties. Among the varieties, V_1 (Pusa Bharati) recorded lowest available potassium content in soil (402.38 kg/ha) and variety V_2 (All Green) showed highest available potassium content in soil (412.36 kg/ha). Application of nutrients exhibited positive effect on potassium content in soil after harvesting. Maximum available potassium content in soil (418.42 kg/ha) was recorded with nutrient levels N_6 (120:70:60 NPK kg/ha) and It was at par with N_5 (100:60:50 kg/ha) and closely followed by treatment N_4 (80:50:40 kg/ha), whereas the minimum available potassium content in soil (393.19 kg/ha) was found under nutrient levels N_1 (00:00:00 NPK kg/ha).

Table 1: Effect of varieties and nutrient levels on growth of palak

Treatment	Fresh weight of plant (g)			Dry weight of plant (g)			Leaf moisture content (%)		
	1st cutting	2nd cutting	3rd cutting	1st cutting	2nd cutting	3rd cutting	1st cutting	2nd cutting	3rd cutting
Varieties (V)									
V_1- Pusa Bharati	21.96	22.80	24.11	3.68	3.89	3.99	83.44	83.09	83.50
V_2 - All Green	20.15	20.58	21.90	3.18	3.17	3.34	84.48	84.78	84.90
S.Em±	0.30	0.47	0.53	0.09	0.10	0.08	0.32	0.50	0.46
CD at 5%	0.87	1.38	1.57	0.25	0.31	0.23	0.93	1.46	1.36
Nutrient levels (N)									
N_1 - 00:00:00 NPK kg/ha	17.27	18.40	19.40	2.36	2.55	2.76	86.42	86.14	85.80
N_2 - 40:30:20 NPK kg/ha	19.18	20.03	20.88	2.63	2.80	2.99	86.31	86.02	85.66
N_3 - 60:40:30 NPK kg/ha	20.39	21.05	22.50	3.09	3.05	3.31	84.82	85.55	85.22
N_4 - 80:50:40 NPK kg/ha	21.56	22.19	23.43	3.66	3.48	3.63	83.03	84.44	84.55
N_5 - 100:60:50 NPK kg/ha	23.25	23.77	24.75	4.14	4.19	4.11	82.22	82.33	83.24
N_6 - 120:70:60 NPK kg/ha	24.67	24.68	27.06	4.70	5.11	5.20	80.97	79.12	80.73
S.Em±	0.51	0.81	0.93	0.15	0.18	0.14	0.55	0.86	0.80
CD at 5%	1.51	2.39	2.71	0.44	0.53	0.40	1.61	2.52	2.36

Table 2: Effect of varieties and nutrient levels on quality and nutrient uptake of palak

Treatment	Quality		NPK Content in plant at harvesting (%)			Available NPK content in soil after harvest (kg/ha)		
	TSS (^{0}Brix)	Iron content of leaves (mg/100 g)	N	P	K	N	P	K
Varieties (V)								
V_1- Pusa Bharati	7.70	13.36	2.919	0.703	3.208	202.25	14.36	402.38
V_2 - All Green	7.10	12.53	2.841	0.683	3.121	209.40	16.34	412.36
S.Em±	0.09	0.26	0.052	0.010	0.047	2.42	0.65	3.22
CD at 5%	0.28	0.76	NS	NS	NS	7.11	1.92	9.43
Nutrient levels (N)								
N_1 - 00:00:00 NPK kg/ha	5.96	10.71	2.630	0.517	2.692	193.26	11.93	393.19
N_2 - 40:30:20 NPK kg/ha	7.26	11.63	2.700	0.577	2.828	199.81	13.01	401.79
N_3 - 60:40:30 NPK kg/ha	7.35	12.64	2.828	0.652	3.070	204.27	14.16	404.97
N_4 - 80:50:40 NPK kg/ha	7.78	13.44	2.928	0.738	3.198	208.68	15.72	410.88
N_5 - 100:60:50 NPK kg/ha	7.89	14.35	3.072	0.813	3.455	212.88	17.06	415.00
N_6 - 120:70:60 NPK kg/ha	8.16	14.90	3.122	0.862	3.743	216.05	20.23	418.42
S.Em±	0.16	0.45	0.091	0.018	0.081	4.20	1.13	5.57
CD at 5%	0.48	1.32	0.266	0.052	0.236	12.32	3.32	16.34

Conclusions

It may be concluded from the findings of the present study that among the different varieties of palak, variety V_1 (Pusa Bharati) recorded superior performance for growth, quality and nutrient uptake, while, nutrient status in soil found higher in variety V_2 (All green). Among the nutrient levels, application of N_6 (120:70:60 NPK kg/ha) recorded highest growth parameters, quality parameters and nutrient uptake. Though combined effect of varieties and nutrient levels was non-significant with respect to all the parameters of palak. However, numerically treatment combination V_1N_6 showed superior performance for growth parameters, quality and nutrient uptake.

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