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Effect of Nitrogen and Phosphorus on Growth Performance of Indian Spinach *Beta vulgaris* var. Bengalensis

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ABSTRACT

India is the world's second-largest vegetable producer, after China. Indian spinach is a leafy vegetable grown inweredia and other regions of the world. Nitrogen and Phosphorus affect the growth performance of Indian spinach *Beta vulgaris* var. Bengalensis. These can be a good alternative to organic fertilizers. Nearly all of the researchers offered suggestions for the careful application of Nitrogen (N) and Phosphorus (P) fertilizers in accordance with the state of the soil and the requirements of the crop in a particular soil and climate. The present investigation has led to the conclusion that at 30 days after sowing, plant height and leaf numbers per plant were significantly highest in treatment of 50 kg N/ha. Nitrogen could be the main component for the high growth rate of the studied species. Phosphorus was found responsible for the enhancement of the leaf in size and weight. Plant height, number of leaves, leaf length, leaf width in 15 days and 30 days, and leaf weight after 30 days of sowing were also recorded. The highest plant height (39.13 cm) was recorded 15 days after sowing in N 50 kg/ha, followed by 38.30 cm in N75 kg ha-1 with 1.58 g. Phosphorus was found responsible for the enhancement of the leaf in size and weight. Treatments had a profound effect on the growth and production of Indian spinach seeds, regardless of growing conditions. The performance of Indian spinach was found to be better during the regional season in the study site.

Keywords: Agriculture, Fertilizer, Growth performance, Indian spinach, Nitrogen, Phosphorus

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INTRODUCTION

Indian spinach (*Beta vulgaris* var. Bengalensis; 2n = 2x = 18) is a well-known leafy vegetable grown in India and other regions of the world. It is a member of the Chenopodiaceae family. Indian spinach, also known as beet leaf in English and Palak in Hindi, is a plant that comes from the Indo-Chinese region. The Indian Council of Medical Research in New Delhi recommends consuming 325 grams of vegetables each day. For nutrient-rich food, leafy vegetables contribute 50 grams, tuber plants 50 grams, and other vegetables like onions 225 grams per day. Yet, as per PJTSAU, the real utilization of 24 g verdant vegetables each day per individual in Telangana territory.

Because of its nutritious, soft, and tender leaves, beetroot is widely grown in India. It is an important part of the daily diet of people who need a lot of nutrients. Spinach beet is plentiful in nutrients, particularly vitamin A and different nutrients like Ascorbic corrosive (70 mg 100 g-1), Riboflavin, and Thiamine. Minerals like Iron and Calcium (380 mg 100 g-1), Folic corrosive and certain measures of Nicotinic corrosive, Pyridoxine, Cancer prevention agents like Carotene, Flavones, Indoles, and Isothiocyanates, fundamental amino acids and so forth. According to Thamburaj and Singh (2015), as a result, it is referred to as "Mineral Mining." India is the world's second-largest vegetable producer, after China, thanks to its diverse climate and seasons. This makes it possible to grow a wide range of vegetables. In 2018-19, the vegetable garden area was 10.1 million hectares, with a production of 185.8 million tons and 18.4 M ha-1, according to the National Horticulture Database, which was published by the National Horticulture Board. The National Horticulture Board says that the vegetable growing area in Telangana province is 140.31 thousand hectares and produced 2548.69 lakh MT in 2018-19.

Biofertilizer is an expansive term utilized in different classifications of bio-inoculants, for example, nitrogen-added substances Azotobacter, phosphate solubilizing Microorganisms, for example, Pseudomonas, Bacillus, Rhizobium, Agrobacterium, and so on., and bacteria like Bacillus, Ferredoxins, and Acidothiobacillus that can be dissolved in potassium. as *B. circulans*, *B. edaphicus* and *B. mucilagenous*. They work well, are good for the environment, are cheap, and can be made money without providing plants with the nutrients they need. Additionally, they help crop plants absorb more nutrients from the soil. Azotobacter, a free-living, aerobic, nonsymbiotic, nitrogen-fixing bacteria, is one of the bio-inoculants that can take the place of some organic fertilizers. Mohandas (1999) found that acetobacter infusion reduces nitrogen fertilizer use by 10 to 20 percent.

To meet the nutritional requirements of the developing world, Indian spinach, which is one of India's most important and popular vegetable plants, should be consumed in the form of at least 50 g of green leafy vegetables per day. During the off-season, growing these fast-growing leafy vegetables in the open under a secure structure like a net shelter in the shade can be a great opportunity. As a verdant vegetable, it has different plant-nourishing necessities, particularly Nitrogen and Phosphorous.

Mei and others (1986) detailed that the leaf count per plant expanded from 11.5 to 15.5 spinach when given NPK and given micronutrients to plant as a foliar splash. In addition, they reported a yield increase of 38% in comparison to spinach with nutrient uptake control.

Amaranthus leaf yield was studied in the field by Gogai and Rajgopal (1986) to see how blurring and nitrogen levels affected it. On the second, third, and fourth cuts, they said that shading lowers yield. Up to 40 kg ha 1, nitrogen levels increased yields.

Suryanarayana Reddy et al., (1986) investigated the impact of micronutrients and NPK in combination on sandy loam brinjal soils. Various medicines included zinc sulfate (25, 50, and 75 kg ha^{-1}) borax (5, 10, and 15 kg ha^{-1}), and copper sulfate (10, 20, and 30 kg ha^{-1}), and 120 kg N, 60 kg P_2O_5, and 60 kg K_2O ha^{-1}. NPK + 75 kg ZnSO4 ha-^{1} had the highest fruit yield (15.03 t ha^{-1}) compared to the control, which had a very low yield (4.25 t ha^{-1}).

Dixit et al. (2007) examined the efficacy of leafy vegetables like spinach, amaranthus, fenugreek, and coriander in both a protected area and an open field setting. According to the findings of the study, when compared to open-field planting, greenhouse culture results in harvests that are two to three times greater than those from outdoor planting. -2.34 kg each for spinach, amaranthus, fenugreek, and coriander) when compared to open field conditions (3.15 kg each for spinach, amaranthus, fenugreek, and coriander). Biemond (2004) found that excessive nitrogen increased leaf mass when estrogen affected the accumulation and separation of solids and nitrogen from spinach. Re-education (NRA) of the Pusa Barathi variety of beet spinach in Uttarakhand measured growth area, dry matter yield, and nitrogen accumulation in the leaves. The recommended fertilizer dose (80:40:50 kg NPK per hectare) produced the highest quality dry matter (456,33 ka / ha), beating out all other treatments. Present study was carried out to look upon field Growth performance of Indian spinach influenced by Phosphorus and Nitrogen contents.

MATERIAL AND METHODS

Study Site

The present investigation was carried out at the Institute of Agriculture Sciences field, Bundelkhand University, Jhansi, Uttar Pradesh, India, during the rabi season of 2017-2018. The study site is at an altitude of 284 meters (935 feet), 25.43° N Latitude, and 78.58° E Longitude. It lies on the plateau of central India, an area dominated by rocky relief and minerals underneath the soil. The soil is fertile, low in available nitrogen, high in phosphorus, and high in potash with a pH of 8.5. Appropriate weather data during the growing season are presented in Table 1 and are shown in Fig. 1.

Soil of the experimental field

The climate of the study area is subtropical monsoon type, characterized by hot and dry summer (except during monsoon season) and mild winter. The average rainfall of the district is about 900 mm. The irrigated area of the district is only 38.93% to net cultivated area. This shows that the maximum cropped area of the district is rained. The soil in the district is deep black cotton soil. The soil sample of the study site was collected and analyzed. The results are presented in Table-2.

Experimental details

Present investigation was carried out with ten treatments of nitrogen and phosphorus including control. Four different concentrations of nitrogen and phosphorus were applied in the experiment. 25kg/ha, 50 kg/ha, 75 kg/ha, and 100 kg/ha amount was used for nitrogen and phosphorus both in three replications. spinach (*Beta Vulgaris var. bengalensis*) was sown in an open field in beds in 1m x 1 m apart from each replication in a randomized block design (RBD). A spacing of 40 cm was applied between rows and plant spacing was 30 cm during rabi season.

Observation of data and Statistical analysis

After sowing growth data was recorded for plant height, number of leaves, leaf length, leaf width in 15 days and 30 days, and leaf weight after 30 days of sowing was also recorded. The observation was taken from ten randomly selected competing plants in each plot for the growth characters. The average value of plants was calculated and used in statistical analysis using some mathematical formulas, JASP, WASP 2.0, and OPSTAT statistical analysis packages.

Mathematical processes

(I) Diversity analysis: The definition of each character was analyzed according to the procedure provided by Panse and Sukhatme (1989) for random block design.

(i) Standard error of mean: Standard error of mean was calculated using the following formula,

$$S.E\,(m) \pm = \sqrt{\frac{MSSe}{r}}$$

Where,

S E(m) ± = Standard error of difference
MSSe = Error mean sum of squares
r= Number of replications

(ii) Standard error of difference: Standard error of difference was calculated using the following formula

$$S.Em(d) \pm = \sqrt{\frac{2\,MSSe}{r}}$$

Where,

S Em(d) ± = Standard error of difference
MSSe= Error mean sum of squares
r = Number of replications

(iii) Critical difference: It was calculated as formula given below

C. D. (5%) = S E(d) x 't' value at 5% level of significance

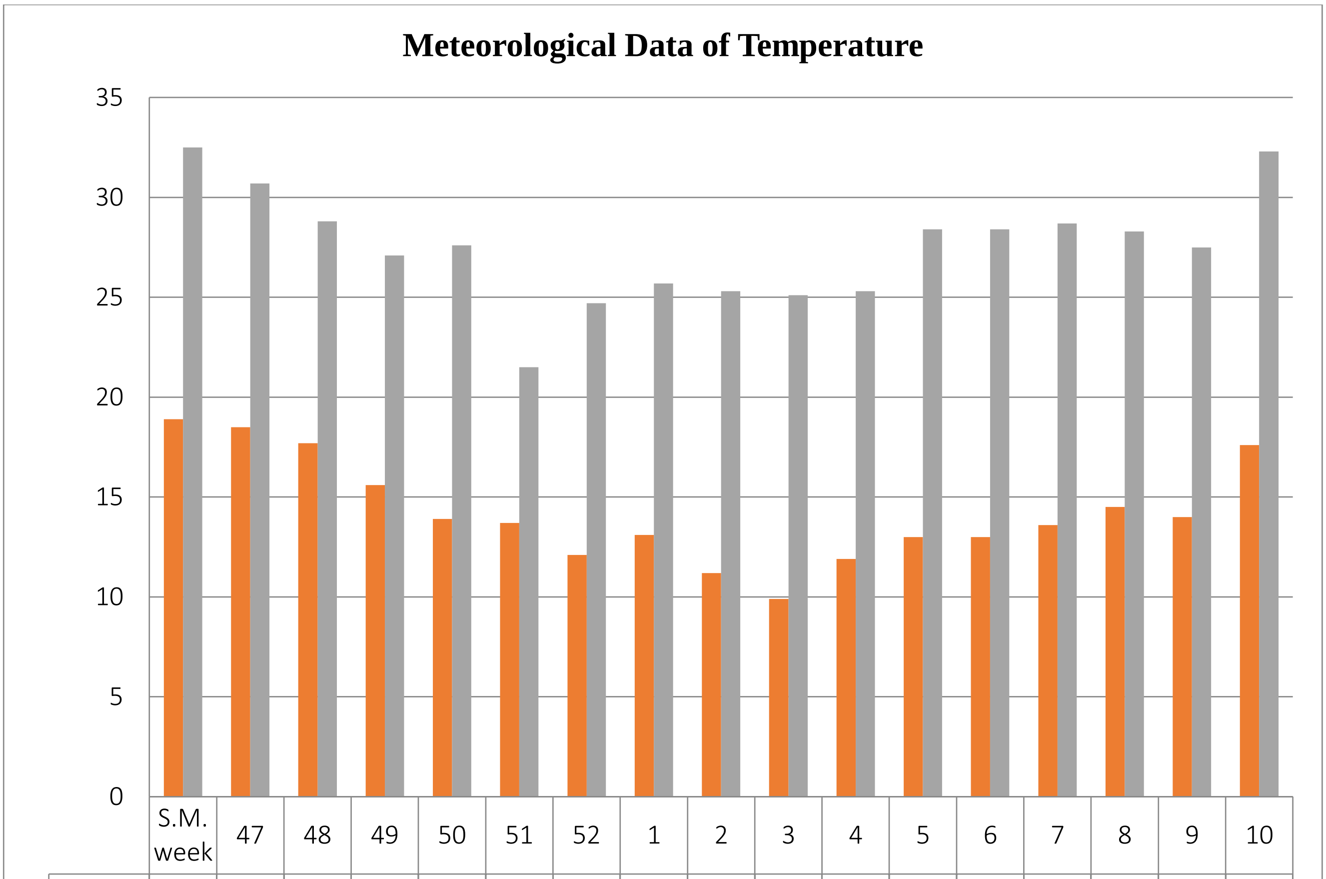
Where,

C. D = Critical difference
S E(d) ± = Standard error difference
't'= t table value at error degree of freedom at 5% level of significance.

Table 1: Meteorological parameters recorded during the period of the investigation (8th November 2017 to 24th March 2018)

S.M. week	Duration	Temperature (^{0}C)		Relative Humidity (%)	Weekly Rainfall (mm)
		Min.	Max.		
47	18 Nov – 24 Nov	18.9	32.5	25.0	0.13
48	25 Nov – 01 Dec	18.5	30.7	28.0	-
49	02 Dec – 08 Dec	17.7	28.8	28.7	1.2
50	09 Dec – 15 Dec	15.6	27.1	32.7	-
51	16 Dec – 22 Dec	13.9	27.6	28.2	-
52	23 Dec – 30 Dec	13.7	21.5	63.2	10.5
01	31Dec – 06 Jan	12.1	24.7	50.0	-
02	07 Jan – 13 Jan	13.1	25.7	42.0	9.2
03	14 Jan – 20 Jan	11.2	25.3	36.7	-
04	21 Jan – 27 Jan	9.9	25.1	32.5	-
05	28 Jan – 03 Feb	11.9	25.3	36.0	-
06	04 Feb – 10 Feb	13.0	28.4	37.7	8.7
07	11 Feb - 17 feb	13.0	28.4	32.7	-
08	18 Feb – 24 Feb	13.6	28.7	26.7	-
09	25 Feb – 03 Mar	14.5	28.3	33.5	-
10	04 Mar – 10Mar	14.0	27.5	29.4	-
11	11 Mar – 17 Mar	17.6	32.3	21.2	-

Source: Meteorological Observatory, Dr. B.R. Ambedkar University of Social Sciences Mhow (M.P.)



S.M. week	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10
Min. 18.9	18.5	17.7	15.6	13.9	13.7	12.1	13.1	11.2	9.9	11.9	13	13	13.6	14.5	14	17.6
Max. 32.5	30.7	28.8	27.1	27.6	21.5	24.7	25.7	25.3	25.1	25.3	28.4	28.4	28.7	28.3	27.5	32.3

Table 2: Physical and chemical composition of the soil

SL. No.	Composition			Method adopted
	Physical	Content	Category	
1.	Organic carbon	0.28	Normal	
2.	Available nitrogen (kg/ha)	196.6	Low	Rapid titration method (Walkley and Black, 1934)
3.	Available phosphorus (kg/ha)	8.0	Medium	Olesen's extraction method (Olesen et al. 1954)
4.	Available potassium (kg/ha)	394.3	High	Flame photometer (Ghosh et al.1981)

RESULTS AND DISCUSSION

The plant height

The Analysis of Variance clearly demonstrated that the palak plant's height reacted significantly to the various levels of phosphorus-containing nitrogen and phosphorus throughout all of the current growth stages.

The highest plant height (39.13 cm) was recorded 15 days after sowing in N 50 kg/ha, followed by 38.30 cm in N75 kg/ha. The lowest level of control was observed in plant height 15 days after sowing.

When compared to the other treatments, the maximum plant height recorded 30 days after sowing was 81.18 cm in the treatment with N 50 kg/ha, followed by 79.93 cm in the treatment with P 50 kg/ha. The control's plant length, on the other hand, was only 61.75 cm. Comparable contrasts in plant level of palak species have been accounted for by Dixit et al. (2007) and Sara et al (2007). N fertilization increases the nitrate content of plant tissue due to high soil N levels (Brown and Smith, 1966, 1967; Hanway and Englehorn, 1958; Macleod, 1965; Perez and Story, 1960; Smith and Sund, 1965; Wright and Davison, 1964). Brown and Smith (1966, 1967) found that most vegetables developed nitrate accumulation when N fertilizer was applied at a rate greater than 50 pounds per acre.

Number of Leaves

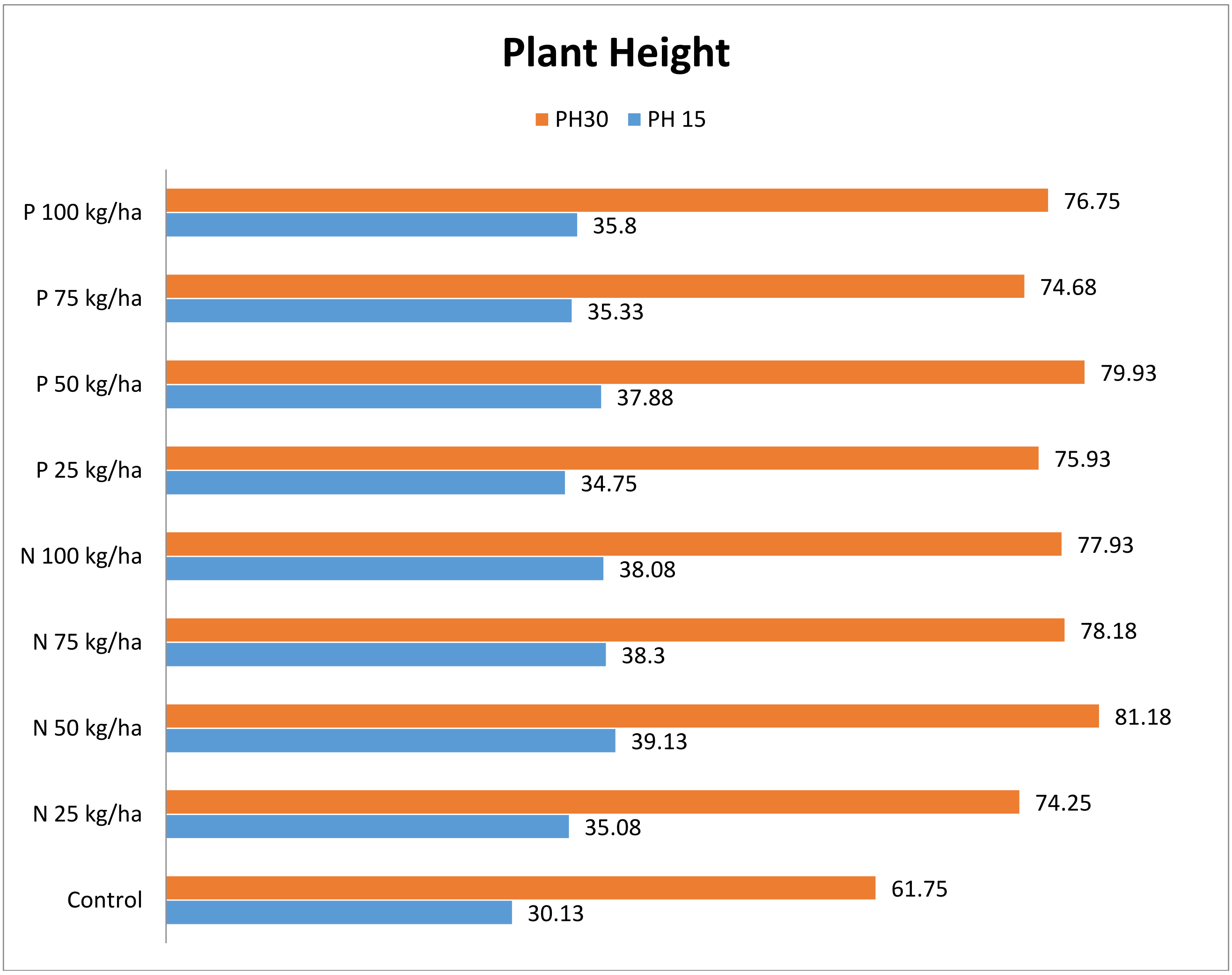
Number of leaves/plants was recorded at 15 and 30 days after sowing. At 15 days after sowing, the significant maximum of 15.80 leaves per plant was recorded in treatment N 50 kg/ha followed by N 100 kg/ha (15.70 leaves). While 6.58 leaves per plant were recorded in control.

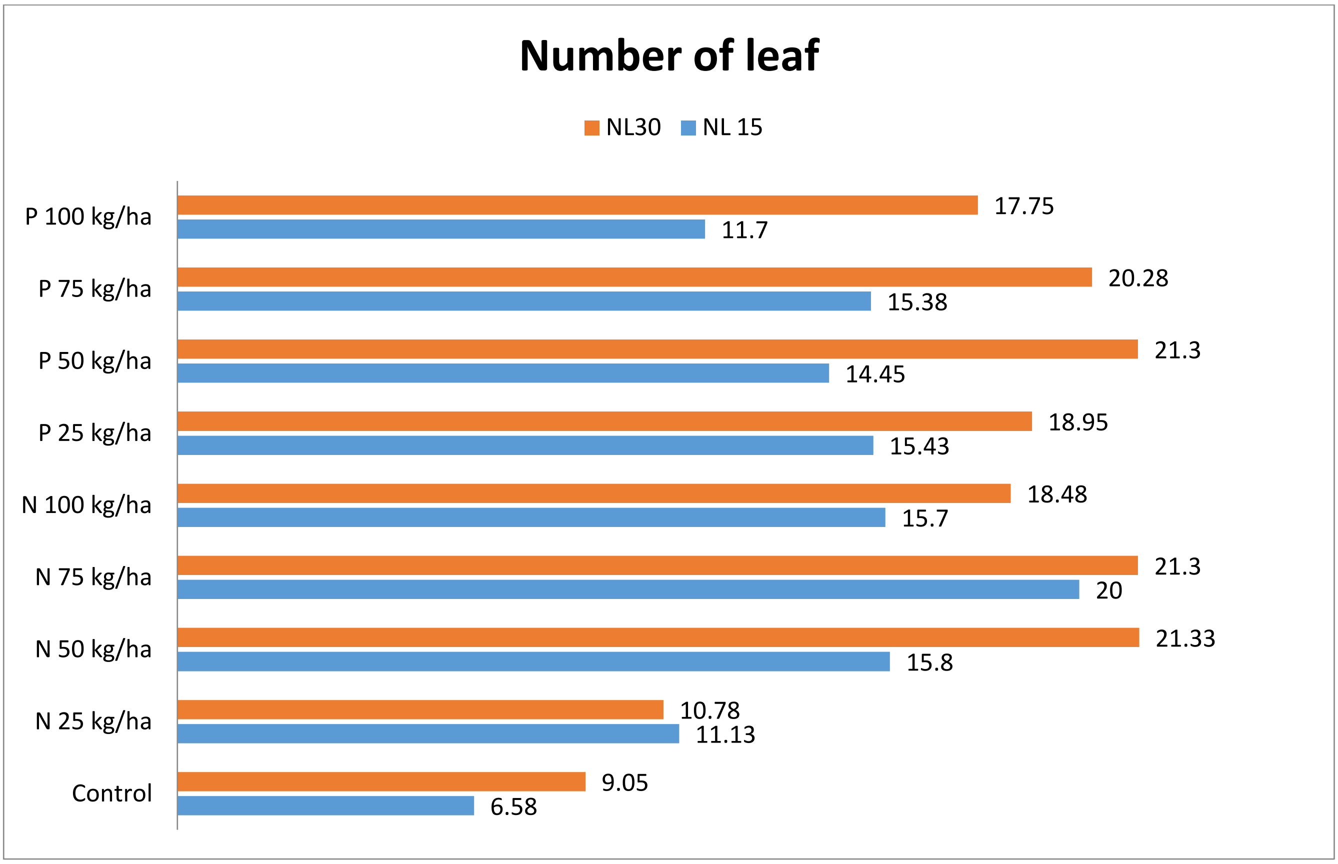
After 30 days of sowing, a maximum (21.33) leaves per plant was recorded in N 50 kg/ha followed by 21.30 leaves per plant in the treatment of N 75 kg/ha and P 50 kg/ha. While a small leaf was recorded in control by Kotadia et al. (2012) and Singh et al. (2013). Nitrogen fertilization may either increase the foraging capacity of the root system and the absorption of certain elements like phosphorus or it may decrease the concentration of other elements because of the increased growth of the plant's tops and roots (Grunes, 1964; Tserling1965). In contrast, other studies have shown that, in most cases, P fertilizer application results in a distinct yield and quality response in crops like lettuce (Alt, 1987; Sanchez et al. 1988; Johnstone et al. 2005). In a similar vein, Soundy and Smith (1992) demonstrated a significant linear correlation between the concentrations of P in lettuce head tissue and soil. The findings of Cleaver and Greenwood (1975), who reported that lettuce required more phosphorus fertilizer than the majority of other vegetables across a variety of soil types, may explain this relationship.

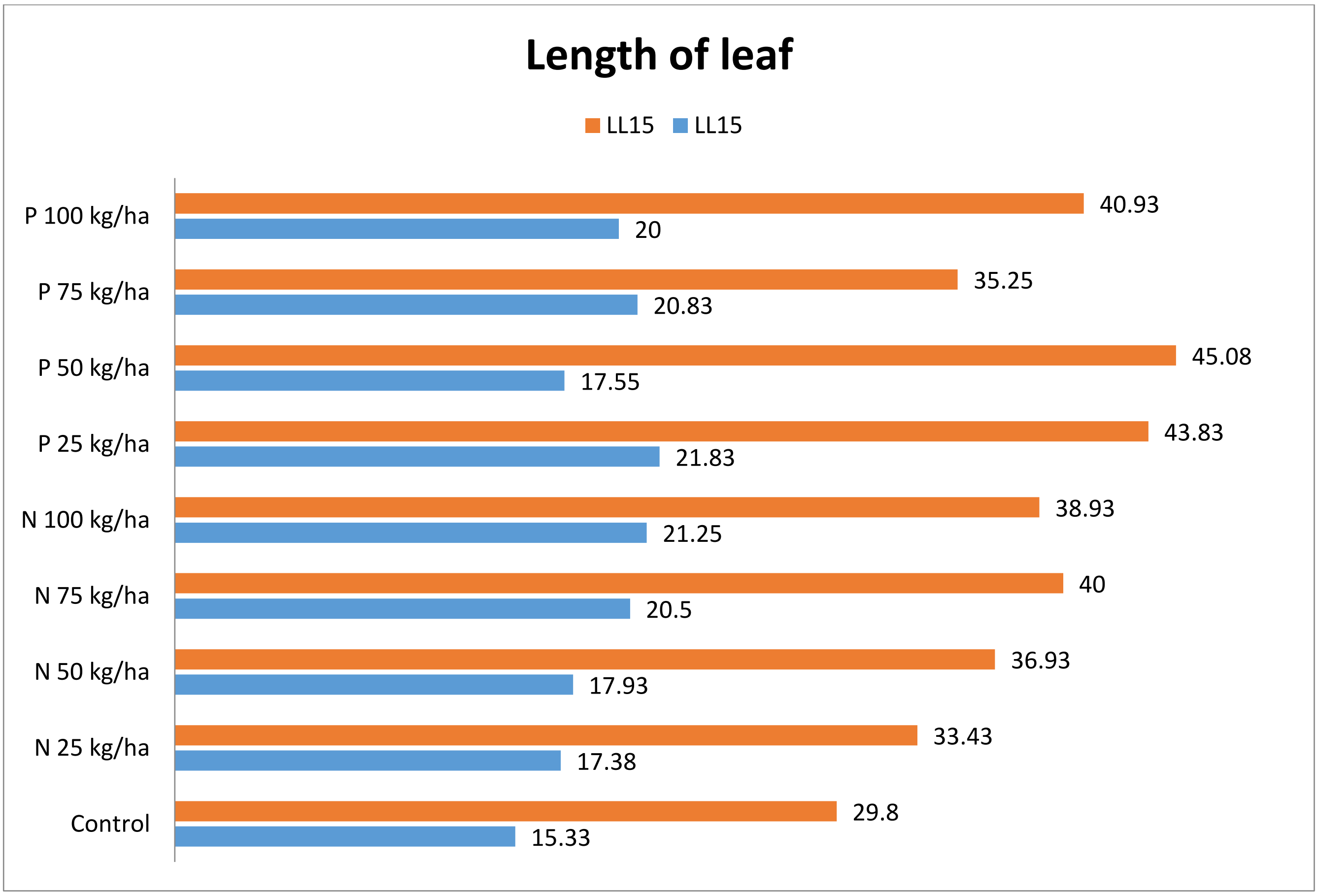
Length of leaf

The significant maximum 21.85 cm long leaf was observed in the treatment of P 25 kg/ha after 15 days of sowing followed by a 21.25 cm long leaf in N 100 kg/ha. Meanwhile, 15.33 cm length was recorded in the control. After 30 days of sowing maximum 45.08 cm long leaf was recorded in P 50 kg/ha followed by 43.83 cm in treatment of P 25 kg/ha. The same variations in the different types of palak leaves were reported by Dixit et al. (2007) and Sara et al. (2007). The improved soil's physical, chemical, and biological properties may be the reason for the increased plant growth in cow manure-treated soils. According to Kashem and Warman (2009), the increased availability of nutrients to the plants is to blame for the rise in productivity that was observed following the addition of compost. (2001, Kashem and Singh;

Warman and Zheljazkov, 2003). Regardless of amendments, the phosphorus concentration in plant parts increased linearly with rates. Higher phosphorus content in the shoot and root is logical because they immediately supply soluble P for immediate plant uptake and accumulation (Tisdale et al., 1985). According to Mengel and Kirkby (1987), nitrogen (N) is one of the most important nutrients that inhibit plant growth, as evidenced by the high demand for vegetable production. Although the application of nitrogen fertilizer can increase the yield of leafy vegetables, excessive use may result in decreased food quality, economic loss, and environmental degradation (Mozafar, 1993; Peng et al. 1996; Darwish et al. 2006; Zhang et al. 2012). Additionally, excessive use of N may increase the concentration of nitrate in spinach, which may be harmful to humans as well as animals (Citak and Sonmez, 2010), as it may cause the production of N-nitrosamines, compounds that have the potential to cause cancer (van Velzen et al. 2008). Numerous health issues, including methemoglobinaemia and gastrointestinal cancer, may result from a high nitrate intake from food and water (Bruning-Fann and Kaneene, 1993a, 1993b). According to Maynard et al. (1976) certain vegetables have a tendency to accumulate more nitrates (NO3) than others because they have an extremely effective uptake system, an ineffective reductive system, or an unfavorable combination of the two. for instance, list spinach as a nitrate accumulator Maynard et al. (1976). In addition, plant assimilation is thought to be improved by the combination of Phi and Pi ions (US patent number 6824584; Young 2004). Forster and others 1998) discovered that Phi did not perform as well as Pi fertilizer, but tomato plants treated with a mixture of Pi and Phi grew better than plants treated with Pi alone. Phosphate has been accounted for to be more dissolvable than Pi, making leaf and root take-up more effective (Lovatt and Mikkelsen, 2006; Watanabe, 2005). This demonstrates that not all plant species can effectively absorb Phi through their roots.




Number of leaf
NL30
NL 15
P 100 kg/ha
P 75 kg/ha
P 50 kg/ha
P 25 kg/ha
N 100 kg/ha
N 75 kg/ha
N 50 kg/ha
N 25 kg/ha
Control
17.75
11.7
20.28
15.38
21.3
14.45
18.95
15.43
18.48
15.7
21.3
20
21.33
15.8
10.78
11.13
9.05
6.58


Length of leaf
LL15
LL15
P 100 kg/ha
P 75 kg/ha
P 50 kg/ha
P 25 kg/ha
N 100 kg/ha
N 75 kg/ha
N 50 kg/ha
N 25 kg/ha
Control
40.93
20
35.25
20.83
45.08
17.55
43.83
21.83
38.93
21.25
40
20.5
36.93
17.93
33.43
17.38
29.8
15.33

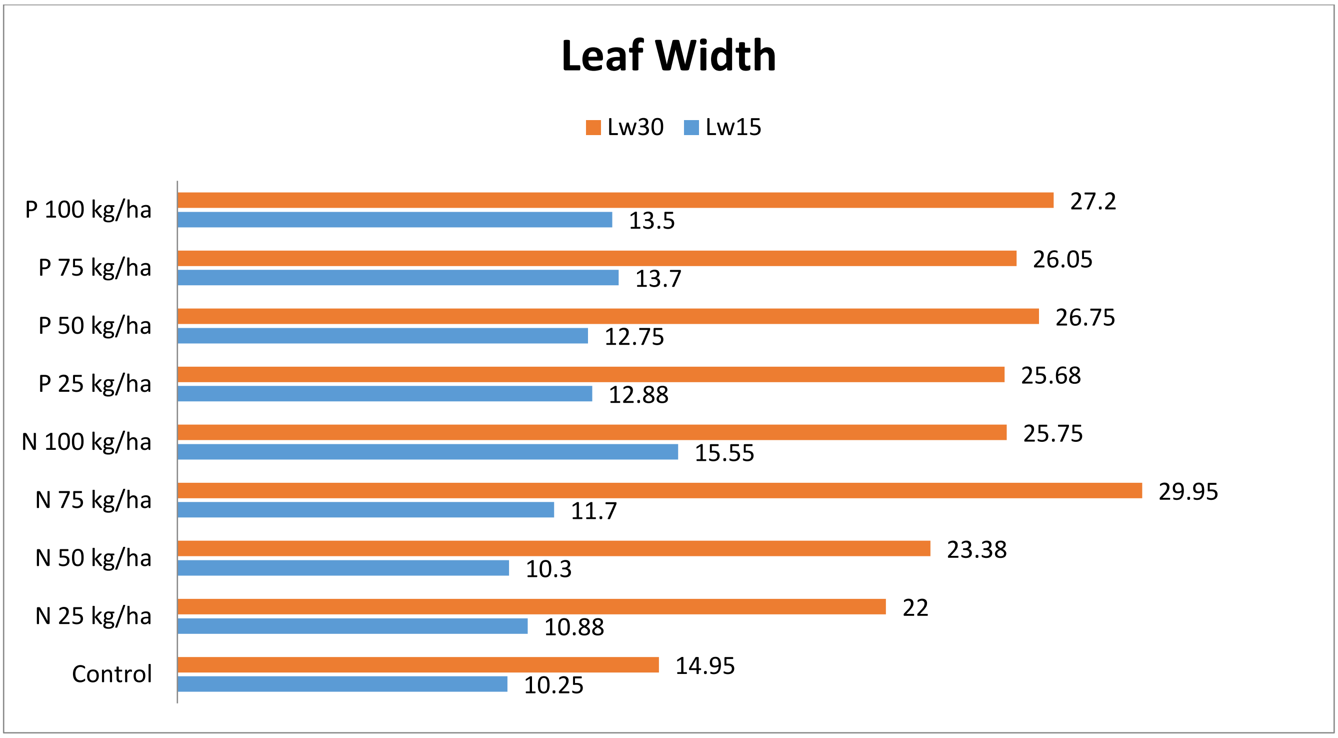


Table 4. Effects of different treatments of nitrogen and phosphorus on growth of Indian spinach after 15 of sowing

Treatment	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)
Control	30.13	6.58	15.33	10.25
N 25 kg/ha	35.08	11.13	17.38	10.88
N 50 kg/ha	39.13	15.80	17.93	10.30
N 75 kg/ha	38.30	20.00	20.50	11.70
N 100 kg/ha	38.08	15.70	21.25	15.55
P 25 kg/ha	34.75	15.43	21.83	12.88
P 50 kg/ha	37.88	14.45	17.55	12.75
P 75 kg/ha	35.33	15.38	20.83	13.70
P 100 kg/ha	35.80	11.70	20.00	13.50
LSD (at 0.05)	1.75	1.08	0.88	0.85
SE	0.60	0.37	0.30	0.29
SD	0.84	0.52	0.42	0.41
C.V. %	3.31	5.27	3.13	4.67

Leaf width

The significantly widest (15.55 cm) leaf in treatment N 100 kg/ha was noted followed by 13.70 cm in P 75 kg/ha and 10.25 cm in control after 15 days of sowing. Moreover, after 30 days of sowing maximum (29.95 cm) leaf length was recorded in N 75 kg/ha followed by 27.20 in P 100 kg/ha. It was brought about by the interaction of nitrogen and phosphorus. Phosphorus acts as a basal dose to boost plant growth and development because it delays leaf decomposition near maturity and increases leaf enlargement, especially in the early stages of growth. Mehta et al. (2010) and Anuja and Jayalaxmi (2011) serve as the foundation for these findings. As photosynthetic biomass contributes to the growth of the tuber and the nutrients collected from the leaves are transferred to the leaf, they pointed out that the growth of leaves above the ground is an indication of the yield of the tuber.

Leaf weight

Increased yields with nitrogen and phosphorus can be attributed to the corresponding increase in leaf area, which was responsible for photosynthetic and photosynthetic growth. The weight of leaf recorded treatment-wise and the mean value are depicted in Table. The treatment of N 100 kg/ha was recorded as significantly superior and gave a maximum (1.68 g) weight of leaf followed by treatment of P25 kg/ha with 1.58 g. The regenerative effect of phosphorus on photosynthesis, phloem loading and localization, and the integration of large molecular weight components into storage organs all play a significant role in increasing leaf weight. Godara et al. (2013) and Kotadia et al. (2012) serve as the foundation for these findings.

In spinach pot experiments, applying N significantly outperformed applying K to increase leaf yield (Ehrendorfer 1964). N fertilization reduced the amount of K in grasses (MacLeod, 1964). Using the N, Kresge and Younts (1963): Orchard grass yield and nutrient content were found to be related to the P ratio of applied fertilizer, with N: Maximum yields required K ratios lower than 2.4:1.

Table 5. Effects of different treatments of nitrogen and phosphorus on the growth of Indian spinach after 30 of sowing

Treatment	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)
Control	61.75	9.05	29.80	14.95
N 25 kg/ha	74.25	10.78	33.43	22.00
N 50 kg/ha	81.18	21.33	36.93	23.38
N 75 kg/ha	78.18	21.30	40.00	29.95
N 100 kg/ha	77.93	18.48	38.93	25.75
P 25 kg/ha	75.93	18.95	43.83	25.68
P 50 kg/ha	79.93	21.30	45.08	26.75
P 75 kg/ha	74.68	20.28	35.25	26.05
P 100 kg/ha	76.75	17.75	40.93	27.20
LSD (at 0.05)	1.62	0.83	0.77	1.10
SE	0.55	0.28	0.26	0.38
SD	0.78	0.40	0.37	0.53
C.V. %	1.46	3.18	1.38	3.05

These results are in line with those of Canali et al. in 2008, they suggested that spinach needs soils with a high fertility level. Biemond (1995) expressed that manure ought to be applied in a few parts and 85 to 120 kg for each ha N would be sufficient as a side dressing. Canali and others, 2008) recommended applying up to 150 kg of nitrogen per hectare to spinach, while Patel et al., 2008 proposed incomplete utilization of ranch yard excrement at the expense of diminished N application for spinach. According to Popat et al. 2009 study, spinach leaf yields increased when NPK was applied at higher rates compared to control or at lower levels. Dua et al., 2010 suggested fertilizing spinach with 30 tons of farm yard manure, 150 kg of nitrogen, 83 kg of phosphorus, and 43.7 kg per hectare. According to Odueso (2011), NPK at rates of 20-10-10 was found to be superior for the growth and yield of spinach. Sajirani et al., 2012 suggested using 45 tons of manure per hectare in addition to 300 kilograms of urea per hectare to increase spinach yields. Nearly all of the researchers offered suggestions for the careful application of N and P fertilizers by the state of the soil and the requirements of the crop in a particular soil and climate.

CONCLUSION

The present investigation has led to the conclusion that at 30 days after sowing, plant height and leaf numbers per plant were significantly highest in treatment of 50 kg N/ha. Nitrogen could be the main component for the high growth rate of the studied species. Phosphorus was found responsible for the enhancement of the leaf in size and weight. Treatments had a profound effect on the growth and production of Indian spinach seeds, regardless of growing conditions. The performance of Indian spinach was found to be better during the regional season in the study site.

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