Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 2229-2231
Received: 25-10-2020
Accepted: 27-12-2020

Vikash Kumar Patel
Department of Horticulture, Faculty of Agricultural Sciences and Technology, AKS University, Sherganj, Satna, Madhya Pradesh, India

Balaji Vikram
Department of Horticulture, Faculty of Agricultural Sciences and Technology, AKS University, Sherganj, Satna, Madhya Pradesh, India

Purnima Singh Sikarwar
Department of Horticulture, Faculty of Agricultural Sciences and Technology, AKS University, Sherganj, Satna, Madhya Pradesh, India

Jaipinaky Sengupta
Department of Horticulture, Faculty of Agricultural Sciences and Technology, AKS University, Sherganj, Satna, Madhya Pradesh, India

Corresponding Author:
Vikash Kumar Patel
Department of Horticulture, Faculty of Agricultural Sciences and Technology, AKS University, Sherganj, Satna, Madhya Pradesh, India

Effect of different levels of nitrogen and phosphorus on growth and yield of spinach (*Spinacea oleracea* L.) cv. all green

Vikash Kumar Patel, Balaji Vikram, Purnima Singh Sikarwar and Jaipinaky Sengupta

Abstract
The experiment was conducted to evaluate the effect of different level of nitrogen and phosphorus on growth and yield of Spinach (*Spinacea oleracea* L.) cv. All Green" during Rabi season of the year 2019-2020 on experimental farm of Department of Horticulture, AKS University, Satna (M.P.). The experiment was laid out in Randomized Block Design comprising of 12 treatments each replicated three times. Each replication was further divided into plots and a total of 36 plots were laid out. The seeds were sown with a spacing of 20cm x 10 cm. Treatments were randomly arranged in each replication, divided into twelve plots. Application of nitrogen 80 kg/ha and phosphorus 40 kg/ha has shown the significant improvement in growth and yield parameters than other treatments. The treatment recorded the plant height, number of leaves per plant, length of leaves, Leaf width, Leaf area, Root length, Leaf: Root ratio, Fresh weight of leaves with Yield kg /ha in spinach were found to be highest in the treatments soil application with nitrogen 80 kg/ha and phosphorus at a rate of 40 kg/ha is congruent in *rabi* session.

Keywords: spinach, nitrogen, phosphorus, leaf thickness, yield

Introduction
Vegetable are rich and comparatively cheaper source of vitamins and minerals. Their consumption in sufficient quantity provides taste and palatability which increases appetite and also provides fair amount of fibre in our diet. They are currently recognized as an important source in maintaining against some degenerative diseases. They also play a key role in the acid produced during the digestion of proteins and fatty food and also provide valuable roughage which promote digestion and help in preventing constipation. Some of the essential nutrients like proteins, minerals and vitamins can be met very well through vegetable.

Spinach (*Spinacia oleracea* L.) is an annual plant species belonging to the family Chenopodiaceae. The closely related species *Spinacia* tetranda is considered to be its ancestor and other related species comprise *Spinacia spinosa*, *Spinacia inermis*, and *Spinacia turkestanica.* The genus originated in South - West Asia, while Spinacia *oleracea* was probably brought in the 14th century by the Arabs to Spain, from where it spread to other countries by the 16th century. Spinach is nowadays an important horticultural species, since its leaves have been used worldwide in human nutrition (Fekry [4] *et al.* In developed countries up to 80% of spinach produced is processed as canned or frozen food. The consumption of vegetables such as lettuce, headless lettuce and spinach is increasing, and they are particularly in demand for mixed salads, both as fresh market products and ready-to-use vegetables.

Application of nitrogen and phosphorus fertilizers has essential role in the development of crop yield and quality of the produce Tomar [9]. Farmers have increased application of nitrogen fertilizers to their land year by year without considering the response of different species to rate of nutrients and their forms. Adequate supply of fertilizers can promote plant growth and increase crop production, but excessive and inappropriate use of chemical fertilizers causes accumulation of compounds in the edible products which have a detrimental impact on human health, cause an environmental pollution and economical losses.

Materials and Methods
The experiment was laid out in Randomized Block Design comprising of 12 treatments each replicated three times. Treatments were randomly arranged in each replication, divided into twelve plots. Detail of treatments combinations viz. T_1 (Without Fertilizer), T_2 (60 kg N/h), T_3 (40 kg P/h), T_4 (80 kg N/h + 40 kg P/h), T_5 (60 kg N/h + 40 kg P/h), T_6 (40 kg N/h + 40 kg P/h), T_7 (80 kg N/h + 30 kg P/h), T_8 (60 kg N/h + 30 kg P/h), T_9 (40 kg N/h + 30 kg P/h), T_{10}

(80 kg N/h + 20 kg P/h), T_{11} (60 kg N/h + 20 kg P/h) and T_{12} (40 kg N/h + 20 kg P/h). The main field was brought to fine tilth by repeated ploughings followed by harrowing. After that rocks and debris were removed from the field soil. Finally it was levelled and replications were demarcated using bund former. Each replication was further divided into plots and a total of 36 plots were laid out. Inorganic and Organic source to be incorporated as per treatments and thoroughly mixed into the soil before sowing. The seeds were sown with a spacing of 20 cm x 10 cm on 21-10-2019. Seeds are directly sown in a well prepared field or beds having sufficient soil moisture. Seeds are sown to a depth of 1cm and after sowing the seeds were properly covered with soil by the use of rake. Seeds of spinach were sown on 24th October - 2019, germination started and completed on 03 November the recording of observations was done 15 days after sowing and subsequent readings were recorded after every 15 days interval. The spinach crop was harvested on 8th January - 2020.

Results and Discussion

The treatment of soil application with 80 kg N/h + 40 kg P/h recorded maximum plant height (38.85 cm) at 60 DAS closely followed by 36.93 cm with T_7 (80 kg N/h + 30 kg P/h) and the minimum (21.76 cm) was recorded with T_0 (Control). Treatment T_4 (80 kg N/h + 40 kg P/h) recorded maximum number of leaves per plant (25.48) at 60 DAS closely followed by 24.83with T_7 (80 kg N/h + 30 kg P/h) and the minimum (14.56) was recorded with T_0 (Control). Treatment T_4 (80 kg N/h + 40 kg P/h) recorded maximum length of leaves cm (24.71 cm) followed by 23.38 cm with T_5 (60 kg N/h + 40 kg P/h) and the minimum (14.59 cm) was recorded with T_0 (Control). Similar findings were found by Nayak and Maji [7] in Palak and Kalidasu *et al.* [6] in coriander were also observed. Treatment T_4 (80 kg N/h + 40 kg P/h) recorded maximum Leaf width (14.94cm) followed by 14.06 cm with T_5 (60 kg N/h + 40 kg P/h) and the minimum (08.41 cm) was recorded with T_0 (Control). Treatment T_4 (80 kg N/h + 40 kg P/h) recorded maximum Leaf area (47.96 cm^2) followed by 47.42 cm^2 with T_5 (60 kg N/h + 40 kg P/h) and the minimum (40.87 cm^2) was recorded with T_0 (Control). The increase of Leaf area due to different treatment combination of nitrogen fertilizer or recommended dose of inorganic fertilizer the Similar findings has been reported by Biemond [3] and Veronika *et al.* [10] in spinach. Treatment T_4 (80 kg N/h + 40 kg P/h) recorded maximum Root length (7.84 cm) followed by 7.58 cm with T_{10} (80 kg N/h + 20 kg P/h) and the minimum (4.17 cm) was recorded with T_0 (Control). Treatment T_4 (80 kg N/h + 40 kg P/h) recorded maximum Leaf : Root ratio (1.94) followed by 1.91 with T_7 (80 kg N/h + 30 kg P/h) and the minimum (1.51) was recorded with T_0 (Control). This is found to be in accordance with the findings of Anuja and Jayalaxmi [1]. The growth observations recorded periodically have exhibited many interesting and significantly architectural variations. The plant height in general was enhanced by more than 60 DAS stage period. Similarly, number of leaves per plant was increased by nearly fourfold up to the same period. The length of leaves, Leaf width and Plant spread was augmented by nearly 60 DAS period. The Leaf area and Root length of Spinach was enhanced slightly during 60 DAS period. The above mentioned progressive growth parameters were, In general, recorded in different levels of N and P treatments. In fact the trend and limit of vegetative growth is mainly governed by the genetically characters inherited in the spinach as well as slightly by the existing agro- climatic conditions. This is found to be in accordance with the findings of Assiouty and Abo-sedera [2]. Treatment T_4 (80 kg N/h + 40 kg P/h) recorded maximum Fresh weight of leaves (387.52g) followed by 378.16 *g* with T_5 (60 kg N/h + 40 kg P/h) and the minimum (284.25 *g*) was recorded with T_0 (Control). Treatment T_4 (80 kg N/h + 40 kg P/h) recorded maximum Yield (7245.69 kg /ha) followed by (7123.40 kg /ha) with T_5 (60 kg N/h + 40 kg P/h) and the minimum (4734.61 kg /ha) was recorded with T_0 (Control). It is the fact that N and P increased the cell elongation and cell division influencing *Juice percentage in* spinach plants. It also accumulated more carbohydrate in plant body which lead to early new leave growth as well as bud initiation, later on which resulted in lengthening of Spinach roots health. The Spinach plants receiving required amount of N and P in an optimum proportion could have results in leaves quality by increasing number of cells. These results are also in conformity with those of Hashimi [5] *et al.* who stated that 200 Kg N ha -1gave the best results in growth and yield in Spinach. Similar results were also obtained by Wahocho [11] *et al.* recorded that plants sprayed with N level (140 kg ha^{-1} gave all the growth and yield contributing traits of spinach. Solangi and Velo [8] highest nitrogen of 125 kg ha-1 resulted in highest plant height, maximum number of leaves plant -1, fresh weight of leaves plant -1, took minimum days to first cut, maximum leaf length, maximum yield plot -1 and maximum kg yield ha -1 of Spinach**.**

Table 1: Effect of different level of nitrogen and phosphorus on growth and yield of Spinach

Treatments	Plant height (cm) 60 DAS	No of leaves / plant 60 DAS	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Root length (cm)	Leaf : Root ratio	Fresh weight of leaves (g)	Yield (kg /ha)
T_1	21.76	14.56	14.59	08.41	40.87	4.17	1.51	284.25	4734.61
T_2	32.61	20.32	19.03	12.78	44.65	6.02	1.74	323.67	6181.55
T_3	23.01	17.61	16.44	10.23	42.51	5.34	1.62	296.48	5387.24
T_4	38.85	25.48	24.71	14.94	47.96	7.84	1.94	387.52	7245.69
T_5	36.47	23.52	23.38	14.06	47.42	7.05	1.89	378.16	7123.40
T_6	35.33	22.76	21.57	13.44	46.77	6.26	1.85	372.82	6951.76
T_7	36.93	24.83	23.12	13.70	46.80	7.51	1.91	366.58	7094.85
T_8	35.89	23.49	22.36	13.42	46.24	6.86	1.86	361.37	6954.42
T_9	35.54	22.81	21.44	12.65	45.49	5.43	1.81	359.11	6712.08
T_{10}	35.67	24.24	21.90	13.86	46.73	7.58	1.87	348.04	6882.43
T_{11}	34.51	22.10	21.45	12.75	45.55	6.25	1.83	337.60	6724.75
T_{12}	33.28	21.76	20.47	12.13	45.61	5.96	1.80	332.41	6576.48
S.Ed (±)	0.57	1.06	0.64	1.15	1.10	0.13	1.13	5.91	0.11
CD at 5%	1.18	2.20	1.32	2.39	2.28	0.27	2.34	12.26	0.23

Conclusion

In conclusion, the growth and development of spinach were significantly affected by the fertilisers applied as well as fertiliser rates. Based on the findings of this study, the recommended fertilisers for optimum in plant height, number of leaves per plant, length of leaves, Leaf width, Leaf area, Root length, Leaf: Root ratio, Fresh weight of leaves with Yield kg /ha in spinach were found to be highest in the treatments soil application with nitrogen 80 kg/ha and phosphorus at a rate of 40 kg/ha is congruent in *rabi* session.

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