Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 2376-2379
Received: 18-01-2020
Accepted: 22-02-2020

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Effect of different levels of boron on growth and yield of mungbean (*Vigna radiate* (L.) Wilczek) under guava (*Psidium guvajava* L.) Based agri-horti system in Vindhyayan region

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Abstract
The present investigation entitled “Effect of different levels of boron on growth and yield of mungbean (*Vigna radiata* (L.) Wilczek) under guava (*Psidium guvajava* L.) Based agri-horti system in Vindhyayan region” was conducted during the *Kharif* season of 2017-2018 at Agricultural Research Farm, R.G.S.C. (BHU), Barakachha, Mirzapur (U. P.). The experiment was conducted in 10 years old guava orchard. The experiment was laid out in randomized block design having seven level of boron (B) with recommended dose of fertilizer (20 N, 40 P and 20 K) kg /ha i.e. control, $N_{20} + P_{40} + K_{20}$ + 1.0 kg B /ha, $N_{20} + P_{40} + K_{20}$ + 2.0 kg B /ha, $N_{20} + P_{40} + K_{20}$ + 3.0 kg B /ha, $N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha, $N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha and $N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha treatments were replicated thrice. Results revealed that application of $N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha recorded significantly higher value of the growth parameters *viz.* plant height (cm), dry matter accumulation (g plant^{-1}) trifoliate leaves, branches plant^{-1} and root nodules plant^{-1} as well as yield and yield attributes like pods plant^{-1}, number of grains pod^{-1}, 1000-grains weight and yield of grain and stover (kg /ha) and economics *viz.* gross income (₹ 103924.7 ha^{-1}), Net return (₹78205.74 ha^{-1}), it’s found statistically at par with $N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha and $N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha. The treatment $N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha under agro climatic conditions of Vindhyan region of Mirzapur was markedly enhanced the yield and net return of mungbean as compared to control under guava based agri-horti system.

Keywords: Mungbean, boron, growth and yield

Introduction
Agroforestry can be defined as an approach to land use that incorporates trees into farming systems, and allows for the production of trees and crops or livestock from the same piece of land in order to obtain economic, cultural, environmental, ecological, benefits (Thevathasan, *et al.*, 2004) [37] especially combating the land degradation (Sharma *et al*., 2017a) [31] problem in the semi arid region. The agroforestry system creates more integrated, diverse, productive, profitable, healthy and sustainable land use system (Sharma *et al*., 2017b) [32].
Pulses in India are considered as the poor man’s only source of protein. Pulses are grown on 29.99 million hectares of land with an annual production of 25.23 million tonnes in the year 2018-2019 and the productivity of pulses 841.0 kg/ha (DES, 2019). Pulses are an important component of diet for being rich vegetarian source of protein and making diet nutritionally balanced. In spite of this, the net/capita availability of pulses has come down over the years from 61 g/day/person in 1951 to 56 g/day/person (DES, 2019).
Pulses are most important crops of India are considered as life blood of agriculture because of their unique position in every known systems of farming, is an indisputable proof. Pulse establish an unexcelled integration of Indian farming as they are the paramount source of the protein in Indian diet which is predominantly vegetarian in nature. Besides being a rich source of protein and a mini N factory, pulses are part and parcel of sustainable agriculture, since they are responsible for improvement of physical, chemical and biological properties of the soils. India produces 22.40 million tonnes of pulses from an area of 29.28 million hectare, however about 5.6 million tonnes of pulses are imported annually to meet the domestic consumption requirement (Pattanayak, 2016) [27]. In India pulse can be produced with a minimum use of resources and hence, it becomes less costly even than animal protein. About 20% of the protein presently available to man, come from pulses in the developing countries (Reddy *et al.*, 1986) [29].
Mungbean is an excellent source of high quality nutritive values containing 24-25% protein, 1.3% fat, 3.5% minerals, 4.1% fibre, 56% carbohydrate and 10% moisture.

It is a short duration crop and can be grown twice in a year i.e. in spring and autumn seasons. Mungbean is an erect plant which is highly branched and is about 60 to 76 cm. tall (Oplinger, *et al*., 1990) [25]. The total area covered under mungbean in India is 34.50 lakh hectare with a total production of 15.91 lakh tones. The coverage of area and its production is maximum in Rajasthan (32.76% & 30.61% of the total area and production) while Maharashtra ranked second in area coverage (11.95%) and production (10.58). Karnataka ranked third in area (8.81%) and Tamilnadu is on third position for production (7.63%). The national yield average is 461 kg/ha. Among various factors, judicious use of fertilizer is of prim importance. It is evident from the literature that application of major nutrients, i.e. NPK improves mungbean yield (Ali *et al*., 2010) [1].

Boron is an essential micronutrient for plants. Among micro-nutrients, boron (B) has been found as a wider use for agronomic and horticultural crops. Boron is associated with one or more of the following processes: calcium utilization, cell division, flowering and fruiting, water relations, and catalyst for certain reactions (Berger, 1949; Sprague, 1951) [4, 34]. Boron is essential to transport of photosynthetic sugars to rapidly meristemic (growing) tissue such as root tips, leaves, buds, storage and conductive tissue (Halvin *et al*. 2005) [13]. Soil pH is regarded as a major factor regulating boron availability in soils. Increasing pH favours its retention by soils or soil constituents (Mezuman and Karen, 1981; Goldberg. 1997) [22, 10]. Reproductive growth, especially flowering, fruit and seed set is more sensitive to Boron deficiency than vegetative growth (Dear and Lipsett, 1987; Noppakoonwong *et al*. 1997) [7, 24]. Thus, boron fertilization is necessary for improvement of crop yield as well as nutritional quality. Mustard as a Brassica crop is very responsive to boron application (Mengel and Kirkby, 1987) [21].

Materials and Methods

The field experiment was conducted during *kharif* season 2017-2018 at Agricultural Research Farm Rajiv Gandhi South Campus, Banaras Hindu University, Barakachha, Mirzapur, and Uttar Pradesh. The experiment was laid out in randomized block design having seven level of boron (B) with recommended dose of fertilizer (20 N, 40 P and 20 K) kg /ha i.e. control, $N_{20} + P_{40} + K_{20}$ + 1.0 kg B /ha, $N_{20} + P_{40} + K_{20}$ + 2.0 kg B /ha, $N_{20} + P_{40} + K_{20}$ + 3.0 kg B /ha, $N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha, $N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha and $N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha each replicated three times. The soil of the experimental field was sandy loam in texture with low drainage. The soil have available nutrients (202.36 N kg /ha, 19.56 P kg /ha and 235.74 K kg /ha), pH 6.42 and EC (dS/m) at 25 0 C 0.01. The mungbean was planted between 10 years old guava orchard which was planted in August, 2007. Green gram was sown in seed bed prepared by indigenous plough on 5th August 2017.Other cultural practices such as weeding, thinning, and gap filling etc. were applied after 16 DAS sowing of mungbean crop. The crop was fully raised as rainfed crop. The 5 plants in each plot were randomly selected and tagged and were subsequently used for recording growth parameters (at 20, 40 DAS and at harvest) and yield attributes by adopting standard procedures. Entire quantity of nitrogen (20 kg N/ha), phosphorus (40 kg P/ha) and potash as per treatments in the form of urea (46% N), single super phosphate (16% P_2O_5), murate of potash (60% K_2O) and boron (10.6%) respectively were applied below the seeds at the time of sowing respectively at the time of sowing in every plot. The seeds of variety 'HUM-16' were sown manually in the rows operated by *kudal* with a spacing of 30 cm x 10 cm. Relatively higher seed rate (20 kg /ha) was used for proper maintenance of plant population. The Green gram was harvested on 7 rd October 2017 from each plot. The Microsoft excel was used as a statistical software package for analyzing the data for the analysis of variance and other statistical parameter (McCullough and Wilson 2005) [20]. Critical difference values at p = 0.05 were used to determine the significance of differences between mean values of treatments (Draper and Smith, 1998) [9].

Result and Discussion

Growth attributes of mungbean

The different levels of boron significantly increased the growth parameters of mungbean (Table 1). Results revealed that all application of $N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha recorded significantly higher value of the growth parameters *viz*. plant height (cm), dry matter accumulation (g plant^{-1}) trifoliate leaves, branches plant-1and root nodules plant/ ha, it's found statistically at par with $N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha and $N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha. The increased growth parameter may be attributed to increased cell division due to sufficient supply of nitrogen, phosphorous, potassium and boron and also due to the genetic character of cultivar (Halvin *et al*. 2005) [13]. Nitrogen being constituent of amino acid, protein, nucleic acid, purine and pyrimidine nucleotides, enzymes, co-enzymes and alkaloids and phosphorous of maleic acid, phytin and phospholipids when supplied in adequate amount of expected to favour the production of protein to the maximum extent resulting into vigorous plant growth (Tahir *et al*. 2013) [36]. Thus plant supplied adequately with all the major nutrients (NPKB) produced more leaves and brought about grater accumulation of photosynthetic, yielding higher dry weight. Application of primary nutrients (NPK) and boron fertilizer proved instrumental in increasing the growth parameters at each growth stage (Mathew *et al*. 2013) [19]. It is an established fact that pollen germination is affected by boron.The boron plays an important role in tissue differentiation and carbohydrates metabolisms. It is also a constituent of cell membrane and maintenance of tissue with regulatory effect on other elements (Parry *et al*. (2016) [26]. Similar results also were reported by Shamsuddoha *et al*. (2011) [30], Chatterjee and bandyopadhyaya (2015) [5], Halwai *et al*. (2016) [11] and Hamza *et al*. (2016).

Yield and yield attributes of mungbean

The different levels of boron significantly increased the yield attributes and yield of mungbean (Table 2). Results revealed that all application of $N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha recorded significantly maximum yield and yield attributes like number of pods plant^{-1} (26.67), pod length (10.59 cm), number of grain pod^{-1} (9.77), test weight (37.78g), grain yield (967.65kg /ha) and straw yield (2661.91 kg /ha), it's found statistically at par with $N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha and $N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha. This might be due to the fact that boron fertilizer increased the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter accumulation leading to flowering, fruiting and pod formation. The effect of boron on yield of mungbean was found to be positive and significant (Mathew *et al*. 2013) [19]. Boron application provides recovery to water stress and thus increase in yield. Introduction of oxidative pressure under water deficit with more concentration of phenolic and reduced H_2O_2, O^{2-} and lipid peroxidation credited to decrease in biological yield (Ruiz *et al*. 2006) [19].

Our results are in agreement with Mathew *et al.* (2013), Mondal *et al*. (2012) [23] and Alam and Islam *et al.* (2016), Tahir *et al.* (2013) [36], Hamza *et al.* (2016) [12].

Bio-economics

The different levels of boron significantly increased the profitability of mungbean cultivation in guava based agri-horti system (Table 3). Results revealed that all application of $N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha recorded significantly higher value of the economics *viz.* gross income (₹ 103924.7 ha^{-1}), Net return (₹78205.74 ha^{-1}), it's found statistically at par with $N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha and $N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha. However, the application of $N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha gave higher value of B: C ratio, and it's found at par with $N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha and $N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha. The economics at a particular B level may be correlated to the higher yield in the respective B application. This is in conformity with the findings of Qudduset *al.*, (2011) [28], Mondal *et al.*, (2012) [23], Singh *et al.*, (2014)[32], Arora *et al,* (2016) [3].

Table 1: Effect of different levels of boron on growth and development of mungbean crop

Treatment	Boron levels	Plant height (cm)			Root nodules plant^{-1} (no.)		Number of trifoliate leaves plant^{-1}			Primary branches/plant (no.)		Secondary branches/plant (no.)		Dry matter accumulation (g.)		
		20 DAS	40 DAS	At harvest	30 DAS	45 DAS	20 DAS	40 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest	20 DAS	40 DAS	At harvest
Control	0 kg /ha	25.35	35.69	36.56	9.93	15.88	4.07	5.92	4.29	5.44	5.83	1.38	2.19	1.37	3.80	3.04
$N_{20} + P_{40} + K_{20}$ + 1.0 kg B /ha	1 kg /ha	28.48	38.51	39.17	11.32	17.59	5.35	7.51	5.65	6.45	6.71	2.11	3.22	1.87	4.13	3.95
$N_{20} + P_{40} + K_{20}$ + 2.0 kg B /ha	2 kg /ha	3.04	41.51	43.95	12.38	21.56	8.25	10.98	8.74	7.58	7.80	2.72	3.93	2.37	4.81	4.96
$N_{20} + P_{40} + K_{20}$ + 3.0 kg B /ha	3 kg /ha	32.82	45.79	48.57	14.08	26.25	10.54	12.54	11.35	9.26	9.45	3.42	4.81	2.82	6.55	6.84
$N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha	4 kg /ha	35.22	48.44	51.21	15.06	30.32	12.04	14.42	12.26	10.19	10.54	4.08	5.23	3.08	8.13	8.36
$N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha	5 kg /ha	35.59	48.54	51.56	15.73	30.75	12.12	14.69	12.32	10.60	10.72	4.21	5.65	3.19	8.29	8.63
$N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha	6 kg /ha	35.94	48.60	51.95	15.95	30.82	12.59	14.74	12.94	10.78	10.96	4.18	5.91	3.30	8.65	8.79
CD (0.05%)	CD (0.05%)	1.65	1.74	2.92	0.97	1.42	1.06	1.16	0.90	0.81	0.89	0.67	0.71	0.31	0.60	2.47

Table 2: Effect of different levels of boron on yield and yield attributes of mungbean crop

Treatment	Pods plant^{-1}	Pod length (cm)	No. of grain pod^{-1}	Test weight	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
Control	17.32	6.38	5.84	31.36	495.90	1688.28	22.71
$N_{20} + P_{40} + K_{20}$ + 1.0 kg B /ha	20.51	7.08	6.67	33.16	566.08	1904.14	22.92
$N_{20} + P_{40} + K_{20}$ + 2.0 kg B /ha	22.16	8.50	7.55	35.06	676.60	2224.99	23.32
$N_{20} + P_{40} + K_{20}$ + 3.0 kg B /ha	24.54	9.51	8.70	36.18	800.14	2458.75	24.55
$N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha	26.14	10.25	9.63	37.55	949.84	2622.83	26.59
$N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha	26.67	10.59	9.77	37.78	967.65	2661.91	26.66
$N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha	26.89	10.85	9.97	37.97	973.94	2673.25	26.71
CD (0.05%)	1.37	0.97	0.76	1.01	52.22	103.68	0.98

Table 3: Effect of different levels of boron on economic of mungbean crop under guava based agri-horti systems

Boron levels	Total cost	Seed return (Rs. ha^{-1})	Straw return (Rs. ha^{-1})	Guava return (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Control	19001	27275	3039	45546	75860	56859	3.0
$N_{20} + P_{40} + K_{20}$ + 1.0 kg B /ha	20580	31135	3427	45546	80108	59528	2.9
$N_{20} + P_{40} + K_{20}$ + 2.0 kg B /ha	23644	37213	4005	45546	86764	63120	2.7
$N_{20} + P_{40} + K_{20}$ + 3.0 kg B /ha	24163	44008	4426	45546	93980	69817	2.9
$N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha	24682	52241	4721	45546	102508	77826	3.2
$N_{20} + P_{40} + K_{20}$ + 5.0 kg B /ha	25200	53221	4791	45546	103558	78358	3.1
$N_{20} + P_{40} + K_{20}$ + 6.0 kg B /ha	25719	53567	4812	45546	103925	78206	3.0

Conclusion

On the basis of highest benefit: cost ratio (3.15) application of $N_{20} + P_{40} + K_{20}$ + 4.0 kg B /ha may be applied in mungbean for profitable production under guava based agri-horti system in Vindhyan region of Mirzapur.

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