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Effect of NPK, boron and sulphur on growth and yield of passion fruit

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ABSTRACT : India is bestowed with a wide range of soil and agro-climatic conditions. Therefore, almost all types of fruit can be grown in one or the other parts of the country. China is the largest producer of fruits followed by India which now accounts for about 10 per cent of world production. Passion fruit belongs to the family Passifloracea, distributed throughout the tropical and subtropical regions of the world. There is need to improve and standardize the nutrient doses by which we increase the production of this fruit. Keeping with these views, the experiment was conducted in the experimental farm, Department of Horticulture, BAU, Ranchi. This experiment consisted of ten treatments including control. The treatments were NPK (300: 150:150 g/vine), NPK (250: 125:125 g/vine), boron 1.2 g/vine, sulphur 24 g/vine, the next four treatments were combination of NPK with boron and sulphur, and two controls. Thus, there were ten treatments, replicated thrice in Randomized Block Design. In all the treatments 2 kg of vermicompost and 0.5 kg of lime were applied as basal dose except absolute control. All the treatments exhibited better results over untreated control and absolute control. Highest yield (56.65 q/ha) was obtained by NPK (250: 125:125 g/vine) + boron 1.2 g/vine which was at par with, NPK (300: 150:150 g/vine) + boron 1.2 g/vine (49.15 q/ha) and NPK (250: 125:125 g/vine) + sulphur 24 g/vine (52.48 q/ha). Thus, NPK (250: 125:125 g/ vine) + boron 1.2 g/vine appeared to be the best treatment in vegetative character, reproductive characters, fruit characters and yield followed by NPK (250:125:125 g/ vine) + sulphur 24 g/vine.

KEY WORDS : NPK, Boron, Sulphur, Growth, Yield, Passion fruit

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Fruit, being a rich source of carbohydrate, protein, minerals, vitamins, etc., are considered very much essential for proper growth and protection of human body from different diseases and disorders. India has different types of soil and agro-climatic conditions. Therefore, almost all types of fruit can be grown. China is the largest producer of fruits followed by India. India contribute about 18 per cent of gross value of agricultural output and 52 per cent of total export earning in agriculture (Shukla *et al.*, 2004). However, due to explosion of population and wastage of the harvested produce, the per capita availability of fruits (40 g against the recommended 120 g per day) is far below the required level. Hence, it is urgently necessary to increase the availability of fruits by increasing the area and the productivity and by checking wastage of the produce. The passion fruit is a high value and export oriented crop, distributed throughout the tropical and subtropical regions of the world (Silva and San Jose, 1994). There are so many species of passion fruit are found but only a few are of commercial importance. Martin and Nakesone (1970) suggested the term passion fruit exclusively to represent the species, *Passiflora edulis* Sins, which contains two forms-purple fruited (*Passiflora edulis* Sins) and yellow fruited (*Passiflora edulis Sins f. flavicarpa* Degener). The purple passion fruit is also known as red or black grandilla or mountain sweety cup and in other language as Lilikai in Hawaii and Linmangkan in Indonesia, while the yellow form is known as yellow grandilla, golden passion fruit, yellow lilikai in Hawaii and parena amarilla in Venezwella.

Passion fruit is a native of Brazil and widely cultivated in South Africa, Australia, Newzealand and Indonesia. Nilgiri hills, Kodaikanal, Coorg, Malabar, Kerala and Himachal Pradesh are the major grown area in India. It occupies an important place among the fruits grown in India. North Eastern parts of India have greater potential for establishing passion fruit globe on commercial scale. It flowers throughout the year; however main harvesting seasons are September-October and January- February, producing about 75 fruits/ vine/year.

Due to lack of knowledge of its nutritive value, its cultivation and standard methods to make processed products, this crop has not gained popularity in this region. It holds a great scope as a commercial crop. Thus, there is considerable scope for expansion. The passion leaves, flower and juice are used in many countries as medicines used in treating nervous disorder, bronchial asthma, insomnia, whooping cough, bronchitis and nervous disorders etc.

Passion fruit cultivation is gradually increasing in India. Investigation had been initiated in many passion fruit growing areas. Very few researches had been carried out regarding cultivation of this fruit. Hence, availability of research reviews about cultivation and storage is also very meagre. Passion fruit is comparatively a new crop for the region. There is also need to improve fruiting and quality of fruit. Presently, availability of research reviews about cultivation in Jharkhand is very meagre. Keeping the above points in view, the present investigation was undertaken to see the effect of nutrients on growth behaviour and to standardize the nutrient doses for growth and yield of passion fruit.

RESEARCH METHODS

Seeds were collected from fully ripped passion fruit and after treated with an appropriate solution, seedlings were raised under poly house in poly tubes. Seedlings of four weeks old having 4-5 leaves and of uniform size, well developed and healthy seedlings were uprooted. Before transplanting of seedlings, roots were dipped in 1 g bavistin per litre of water solution. Transplanting was followed by irrigation and whenever necessary. First fertilizer was applied at 30 days after transplanting at the time of fertilizer application, weeding, hoeing and earthing up whenever necessary were done throughout the growing period. Very few gap filling were done by transplanting uniform, healthy and well developed seedlings of the same age. The fertilizer was applied as per treatment and as per schedule.

Height of the main stem of all the tagged plants was recorded from the ground level of the growing to top shoot. It was measured by a meter scale at a 30 days interval and then the average height (length) of vine in each treatment was calculated. The total numbers of leaves, number of secondary branches, girth of main stem of all vines was counted at an interval of 30 days and then average number of leaves in each treatment was calculated. Observation of flowering and fruiting characters were recorded on five randomly tagged shoots.

Treatments :

T_1 - NPK (300:150:150 g^{-1}vine)
T_2 - NPK (250:125:125 g^{-1}vine)
T_3 - Boron (1.2 g^{-1} vine)
T_4 - Sulphur (24 g^{-1} vine)
T_5 - NPK (300:150:150 g^{-1}vine)+Boron (1.2 g^{-1} vine)
T_6 - NPK (250:125:125 g^{-1}vine)+Boron (1.2 g^{-1} vine)
T_7 - NPK (300:150:150 g^{-1}vine)+Sulphur(24 g^{-1} vine)
T_8 - NPK (250:125:125 g^{-1}vine)+Sulphur(24 g^{-1} vine)
T_9 -Control
T_{10}- Absolute control (without vermin compost)

(Note: - A uniform dose of 2kg vermicompost + 500g lime per pit during planting).

Experimental design was RBD with 10 treatments replicated thrice, plant spacing were 3x2m in plot size 4 pits/ line/ treatment. Total number of plots was 30 lines with four plants in each line. No. of plants per line was 4 and number of plants per treatment were 4x3=12.

RESEARCH FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Vine length after transplanting :

Data on vine length of passion fruit at different days after transplanting (DAT) have been given in Table 1. The maximum vine length of passion fruit 12.28 cm and 24.18 cm at 30 and 90 DAT, respectively was recorded with application of 300:150:150g NPK+ 1.2g boron (T_5) closely followed by T_1 (11.8 cm). The minimum vine length 3.33 cm and 15.63 cm were recorded in case of absolute control.

At 150 and 330 DAT, application of 300:150:150g NPK+ 1.2g boron vine^{-1} (T_5) resulted in maximum vine length 76.43 cm and 299.53 cm, respectively which were at par with T_1 (70.48 cm), T_2 (67.88 cm), T_6 (60.53 cm), T_7 (74.50 cm) and T_8 (71.43 cm). The minimum vine length 15.63 cm and 177.60 cm were recorded in case of absolute control.

At 210, 270 and 390 DAT, application of 300:150:150g NPK+ 1.2g boron vine^{-1} (T_5) resulted maximum vine length 118.95 cm, 175.15 cm and 366.33 cm, respectively which was at par with T_1 (111.78 cm), T_2 (109.15), T_3 (100.68 cm), T_4 (99.40 cm), T_6 (107.80 cm), T_7 (116.00 cm) and T_8 (107.53 cm). The minimum vine length 74.95 cm, 114.85 cm and 211.47 cm, respectively were recorded in case of absolute control. All the treatment showed better performance compared to absolute control.

Total number of leaves per vine after transplanting:

Data on effect of different treatments on number of leaf have been given in Table 2. At 30, 90, 150 and 210 DAT the maximum number of leaves 10.55, 21.38, 50.23 and 83.48, respectively were recorded in case of application of nutrients @ 300:150:150g NPK+ 1.2 g boron (T_5) but 30 and 90 days after transplanting it was

Table 1 : Effect of different nutrients on vine length (cm) after transplanting

Treatments		30 days	90 days	150 days	210 days	270 days	330 days	390 days
T_1	300:150:150 g NPK vine^{-1}	11.8	23.58	70.48	111.78	171.53	291.33	358.23
T_2	250:125:125 g NPK vine^{-1}	10.53	21.48	67.88	109.15	168.15	281.60	353.27
T_3	1.2 g boron vine^{-1}	7.00	17.45	54.00	100.68	156.35	259.83	326.30
T_4	24 g sulphur vine^{-1}	5.75	16.78	51.95	99.40	155.20	256.27	321.67
T_5	300:150:150:1.2 g NPKB vine^{-1}	12.28	24.18	76.43	118.95	175.15	299.53	366.33
T_6	250:125:125:1.2 g NPKB vine^{-1}	10.55	20.6	60.43	107.80	169.20	290.17	359.63
T_7	300:150:150:24 g NPKS vine	11.28	20.83	74.50	116.00	172.68	295.57	364.87
T_8	250:125:125:24 g NPKS vine^{-1}	10.93	21.28	71.43	107.53	169.63	293.63	360.43
T_9	Control	5.1	16.75	41.38	78.75	123.75	185.80	223.57
T_{10}	Absolute control	3.33	15.63	38.50	74.95	114.85	177.60	211.47
S.E.±		0.19	0.65	7.75	13.00	15.26	13.34	24.45
C.D. (P=0.05)		0.54	1.90	22.23	37.31	43.81	38.31	70.18
CV %		4.20	6.54	12.25	7.75	9.66	7.30	10.77

Table 2 : Effect of different nutrients on number of leaves (nos.) after transplanting

Treatments		30 days	90 days	150 days	210 days
T_1	300:150:150 g NPK vine^{-1}	9.45	18.43	46.28	80.03
T_2	250:125:125 g NPK vine^{-1}	7.53	16.38	43.98	77.80
T_3	1.2 g boron vine^{-1}	6.50	13.58	38.40	71.30
T_4	24 g sulphur vine^{-1}	5.93	13.65	40.00	72.93
T_5	300:150:150:1.2 g NPKB vine^{-1}	10.55	21.38	50.23	83.48
T_6	250:125:125:1.2 g NPKB vine^{-1}	7.58	14.73	43.65	76.70
T_7	300:150:150:24 g NPKS vine	9.38	19.58	48.83	83.45
T_8	250:125:125:24 g NPKS vine^{-1}	8.53	18.45	47.65	81.88
T_9	Control	5.60	13.33	35.75	67.30
T_{10}	Absolute control	4.40	11.15	33.60	64.15
S.E.±		0.19	0.21	0.60	0.45
C.D. (P=0.05)		0.52	0.61	1.79	1.32
CV %		4.72	2.62	10.50	11.09

closely followed by T_1 (9.45) and T_7 (19.58), respectively whereas at 150 and 210 DAT, 300:150:150g NPK+ 1.2g boron (T_5) was at par with T_7 (48.83) and T_7 (83.45), respectively. The minimum number of leaves 4.40, 11.15, 33.60 and 64.15 were recorded in case of T_{10} absolute control. But after 210 DAT the leaves of passion fruit started falling. All the treatment showed better performance compared to absolute control.

Total number of secondary branches per vine after transplanting :

Table 3 showed the treatment effects on number of secondary branches which was significant. At 270 and 390 DAT, the maximum number of secondary branches 12.60 and 20.60 was recorded in case of 300:150:150g NPK+ 1.2g boron which was closely followed by T_7 (11.88) and at par with (18.59), respectively. While the minimum value 7.05 and 12.20, respectively were recorded in case of T_{10} absolute control.

Plant girth after transplanting :

Data on effect of nutrient management on plant girth are also given in Table 3. The maximum value 4.02 cm was recorded in T_5 (application 300:150:150g NPK+ 1.2g boron) which was at par with T_6 (3.83), T_7 (3.94) and T_8 (3.72). While the minimum value 2.55 cm was recorded in case of (T_{10}) absolute control. All the treatment showed better performance compared to absolute control.

Days to flower initiation after transplanting :

Data on effect of nutrient management on days taken for flower initiation have been given in Table 4. With respect to days taken for flower initiation after transplanting, the minimum days taken for flower initiation (201 days) was recorded in T_6 (application 250:125:120g NPK+ 1.2g boron) which was at par with T_1 (211.50), T_2 (210.42), T_3 (216.60), T_4 (217.50), T_5 (208.64), T_7 (207.27), T_8 (204.74) and T_9 (218.47). The maximum days taken for flower initiation (265.68 days) were resulted in (T_{10}) absolute control.

Days taken for 50 per cent flower initiation after transplanting :

The minimum days taken for 50 per cent flower initiation after transplanting (235.41 days) was recorded in T_5 (application 250:125:120g NPK+ 1.2g boron) which was at par with T_6 (230.66), T_7 (233.01) and T_8 (231.93). On the other hand, the maximum days taken for 50per cent flower initiation (265.68 days) were resulted in absolute control.

Days taken to fruit set after transplanting :

The minimum days taken for fruit set after transplanting (257.44 days) was recorded with T_6 (application 250:125:120g NPK+ 1.2g boron) which was closely followed by T_8 (262.37). On other hand, the maximum (297.22) days taken for fruit set after transplanting was recorded in absolute control which was closely followed by T_9 (283.22).

Days taken to fruit maturity after transplanting :

Days taken for fruit maturity after transplanting, minimum day (319.47 days) was recorded in T_6 (application 250:125:125g NPK+ 1.2g boron) which was

Table 3 : Effect of different nutrients on number of secondary branches and plant girth after transplanting (nos.)

Treatments		270 days	390 days	Plant girth
T_1	300:150:150 g NPK vine^{-1}	10.55	15.98	3.38
T_2	250:125:125 g NPK vine^{-1}	9.38	14.56	3.35
T_3	1.2 g boron vine^{-1}	9.20	14.58	3.14
T_4	24 g sulphur vine^{-1}	8.60	13.93	2.59
T_5	300:150:150:1.2 g NPKB vine^{-1}	12.60	20.60	4.02
T_6	250:125:125:1.2 g NPKB vine^{-1}	10.85	16.66	3.83
T_7	300:150:150:24 g NPKS vine	11.88	18.59	3.94
T_8	250:125:125:24 g NPKS vine^{-1}	11.23	17.45	3.72
T_9	Control	7.60	13.60	3.00
T_{10}	Absolute control	7.05	12.20	2.55
S.E. ±		0.12	0.76	0.20
C.D. (P=0.05)		0.36	2.28	0.58
CV %		5.13	6.93	11.72

closely followed by T_8 (335.04). The maximum days taken for fruit maturity (369.75 days) were obtained in (T_{10}). All the treatment showed better performance compared to absolute control.

Fruit character (Fruit length, breadth, weight and volume) of passion fruit :

Data on effect of different treatments on fruit length, breadth, weight and volume have been given in Table 5. The treatment effects on all the fruit characters were significant. The maximum fruit length, breadth, weight and volume 7.68 cm, 7.30 cm, 82.50 g and 143 cc, respectively were recorded in case of T_6 (application 250:125:125g NPK+ 1.2g boron). But maximum fruit length was closely followed by T_5 (6.80 cm) and in case of maximum breadth treatment T_2, T_5 and T_7 were at par whereas in volume of the fruit T_5 and T_8 were at par with maximum volume. The minimum fruit characters were observed in case of absolute control.

In this investigation different vegetative, reproductive and fruit characters of the vine were markedly influenced by levels of different treatments used for experimentation. A critical examination of the results recorded in this investigation revealed that nitrogen had pronounced effect on vine length. The average number of leaves, secondary branches and plant girth were increased to higher doses of nitrogen.

It may be concluded that the higher dose of NPK along with boron were responsible for vigorous plant growth. Vine treated with NPKB (300:150:150:1.2 g/vine/year) showed the maximum foliage. This is in conformity with the findings of Borges *et al*. (2002).

Table 4 : Effect of different nutrients on reproductive characters (days)

Treatments		Days to flower (days)	Days to 50% flowering (days)	Days to fruit set (days)	Days to maturity (days)
T_1	300:150:150g NPK vine^{-1}	211.50	243.44	274.62	346.02
T_2	250:125:125 g NPK vine^{-1}	210.42	242.72	272.61	344.49
T_3	1.2 g boron vine^{-1}	216.60	246.60	278.48	349.72
T_4	24 g sulphur vine^{-1}	217.50	249.43	280.86	352.50
T_5	300:150:150:1.2 g NPKB vine^{-1}	208.64	235.41	267.47	339.68
T_6	250:125:125:1.2 g NPKB vine^{-1}	201.16	230.66	257.44	319.47
T_7	300:150:150:24 g NPKS vine	207.27	233.01	266.51	337.73
T_8	250:125:125:24 g NPKS vine^{-1}	204.74	231.93	262.37	335.04
T_9	Control	218.47	252.46	283.22	352.59
T_{10}	Absolute control	265.68	280.01	297.22	369.75
S.E.±		9.04	2.34	1.57	2.04
C.D. (P=0.05)		26.38	6.81	4.49	5.85
CV %		8.31	1.92	33.60	10.69

Table 5 : Effect of different nutrient on fruit character after transplanting

Treatments		Fruit length (cm)	Fruit breath (cm)	Fruit weight (g)	Fruit volume (cc)
T_1	300:150:150 g NPK vine^{-1}	6.15	5.83	65.33	125.88
T_2	250:125:125 g NPK vine^{-1}	6.50	6.05	69.13	129.78
T_3	1.2 g boron vine^{-1}	5.58	5.30	62.45	114.44
T_4	24 g sulphur vine^{-1}	5.30	5.00	59.13	103.33
T_5	300:150:150:1.2g NPKB vine^{-1}	6.80	6.55	78.18	139.10
T_6	250:125:125:1.2 g NPKB vine^{-1}	7.68	7.30	82.50	143.81
T_7	300:150:150:24 g NPKS vine	6.25	5.98	69.23	132.03
T_8	250:125:125:24 g NPKS vine^{-1}	6.35	6.03	71.40	142.90
T_9	Control	5.60	5.25	61.78	105.58
T_{10}	Absolute control	5.10	4.73	48.03	99.78
S.E. ±		0.11	1.11	0.87	2.33
C.D. (P=0.05)		0.31	1.34	2.54	6.79
CV %		3.48	1.25	2.61	3.76

The soil application of boron in the form of borax resulted in promotion of vegetative growth might be due to enforcement photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and cell elongation, photosynthetic activity, respiration as well as growth of plant improved by boron (Lal and Rao, 1954).

In reproductive character the earliness is desirable. First flowering took place 201-265 days after transplanting. In general application of NPKB slightly induced earliness. The 50 per cent flowering, first fruit set and maturity also followed the same trend.

The process of flowering and fruiting involve cell division, cell elongation and cell enlargement. The earliness of flowering and fruit setting may be explained in the light of the hypothesis advanced by Witter and Bukovac (1962), who suggested that practically every chemical or group of chemicals which enhance cell-division and cell-enlargement would likewise accelerate floral initiation and fruit setting. Early flower bud differentiation and fruit set with application of nitrogen alone and in presence of phosphorus, potash and boron might be due to accumulation of optimum quantity of carbohydrate reserves.

As we know, boron governs many physiological and bio-chemical plant processes. Application of boron resulted in promotion of flower, all possibly due to the promoting effect of boron on cell division and elongation process Dutta (2004).

Vine treated with NPKB (250:125:125:1.2 g/vine/year) showed the earliness in reproductive character. Similar findings were observed by Natal *et al*. (2004) and Russel (1957). The application of different levels of NPKB was effective in increasing maximum fruit character. It was observed that lower level of NPK induced more fruit length, fruit breadth fruit weight and fruit volume than higher dose.

Fruit size, significant increase in fruit weight, was also obtained with boron treatment. These observations are in consonance with Brahamchari and Shreshtha (1997) and Haque and Ibrago (1994) in guava. The possible reason behind increasing fruit weight might be due to hormonal mediated direct transport, accumulation and ensure balanced partitioning of photosynthetic assimilates to the developing fruit than by enabling the shoot to meet the nutritional requirement of fruits throughout their development.

Keeping in view the importance of these nutrients in plant metabolism, the present investigation was carried out on passion fruit to find out best combination of these elements for better growth and yield of passion fruit under Chhotanagpur agro climatic zone of poor farmers.

Nitrogen, phosphorus, potash and sulphur are among the macro-metabolic elements, boron is micro-metabolic element essential for plants, for beneficial effects upon growth yield and quality for a crop.

Nitrogen is the important constituent of aminoacids, acidamides, auxin, purines, pyrimidines pigments, alkaloids and co-enzymes. Chlorophyll, which is essential for photosynthesis, contains nitrogen. Nitrogen induces profuse vegetative growth and its application helps in increasing the photosynthetic assimilation. Nitrogen increases the level of auxin in plants. This auxin helps in accelerating the cell-elongation and cell enlargement in different plant organs. The assimilation of photosynthetic compound together with cell enlargement might have caused the plants to produce more vines.

Phosphorus is absorbed by the plants as ($H_2PO_4^-$) ion. Phosphorus is mostly found in plants as a constituent of nucleic acids, phospholipids, the enzymes NAD and NADP and most important as a constituent of ATP. Thus, phosphorus is involved in the synthesis of protein and fatty acids, hydrogen-transfer, photosynthesis, glycolysis, respiration, which suffice its essentiality to plant. A very large proportion of phosphorus accumulates in the seed and fruit during the period of their development. The role of phosphorus and nitrogen in plant metabolism are inter-related in number of ways. Inorganic nitrogen compounds are rapidly absorbed and accumulated in plant tissues, when phosphates are low. When available phosphates are abundant, the absorption of inorganic nitrogen compounds is decreased. Therefore, the application of phosphatic fertilizers may alter the nitrogen balance to the plant resulting in earlier maturation of plant that occurs when available phosphorus is high, and delay in reaching maturity due to phosphorus deficiency.

Potassium is a monovalent cation with a high mobility in the plant both at the cellular level and in transport in the xylem and phloem. Potassium in the same way is involved in the synthesis of proteins from amino-acids. Carbohydrate metabolism is also affected by in-adequate supply of potassium. Photosynthesis is checked and respiration is increased by potassium deficiency. Generally, a plant deficient in potassium is stunted in growth.

Boron occupies an impact position of all elements which are necessary for the growth of the plants. However, the need for boron is least understood. It is taken up by the roots and transported to the other parts of the plant via xylem. It is mainly present at a borate ester in the cell membrane. There are no enzymes known that contain boron or which are activated by boron. However, there are indications that cis-diol borate complexes can be formed with components present in or on membranes. The formation of these complexes might influence the activity of membrane bound enzymes. The functions of boron are mainly extra cellular. The element is involved in lignifications of the cell wall and in differentiation of xylem-A deficiency of boron immediately results in inhibition of the length growth of the primary and secondary roots.

Sulphur is taken up by the roots as SO_4 at a relatively slow speed. As nitrate, sulphur has to be reduced first before it can be used for the synthesis of sulphur containing compounds like amino acids, proteins and enzymes. Sulphur is incorporated in sulpholipids and polysaccharides in non-reduced form.

Thus, nitrogen, phosphorus, potash, boron and sulphur are responsible for better growth and yield of crop. They must be supplied to the plant in optimum quantity for maximizing production of the crop. Their deficiency in plants will result in retarded growth, low yield and poor quality of the produce.

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