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Effect of phosphorus and potassium on yield and quality characters of bitter gourd (*Momordica charantia* L.) ecotype 'Mithipagal'

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Abstract
A field experiment was conducted at Experimental Farm, Department of Horticulture, Faculty of Agriculture, Annamalai University, Tamil Nadu, India during 2013-2014 on effect of Phosphorus and Potassium on growth and yield characters of bitter gourd ecotype 'Mithipagal'. The treatments comprised of four levels of Phosphorus (0, 30, 60 and 90 kg ha^{-1}) and three levels of Potassium (0, 40 and 80 kg ha^{-1}) comprised of twelve treatment combinations under Factorial Randomized Block Design with three replications. Nitrogen @90 kg ha^{-1} was applied in all treatments as constant dose except the control. Among the graded levels, P_3K_2 (Phosphorus 90 kg ha^{-1}+ Potassium 80 kg ha^{-1}) registered the maximum values in yield parameters *viz,* number of fruits $plant^{-1}$, fruit weight, fruit length, fruit diameter, fruit volume, fruit yield $plant^{-1}$ and fruit yield ha^{-1}. However, it was closely followed by P_2K_2. The maximum values of quality characters were found with the treatment combination of P_3K_2, which registered the maximum Ascorbic acid content and Total soluble solids.

Keywords: Bitter gourd, *Momordica charantia*, yield and quality

Introduction
India is a country with different agro climatic zones ranging from cool temperate to hot tropical zones on which a large number of vegetable crops are grown. The nutritive values of vegetables are having great impact on our diet. They are excellent source of proteins, vitamins, carbohydrates and mineral like calcium and iron. They also have the noteworthy, medicinal values which are used in some traditional medicines. India is producing 93.92 million tones of vegetables from 624.5 million hectares enabling to secure the 2^{nd} rank in the World next to china (Brij Bala and Sharma, 2006) [1]. Our country shares about 12 % of the world output of vegetables from the 2 % of the cropped area.

Bitter gourd (*Momordica charantia* L.) is one of the most popularly grown warm season vegetable crops in South East Asia. It is a member of the Cucurbitaceae family along with cucumber, watermelon, snake gourd and musk melon. Bitter gourd is also widely grown in Tamil Nadu with an area of over 1,074 hectares with an annual production of 12.80 thousand tones. The average production is 10-15 tons per hectare under normal management practices. Depending on location, bitter gourd is also known as bitter melon, Karela or balsam pear. Apart from the small fruits, which are called as 'Mithipagal', it is cultivated in almost parts of the India including Tamil Nadu. It is a trailing climber annual, which branches freely, and semi angled monoecious crop duration of 100-120 days. The importance of bitter gourd has been long recognized due to its high nutritive value and medicinal properties.

It is monoecious and is available with range of male and female sex ratio. It exhibits different constraints in increasing the production, out of this sex expression is also one of the most important one. Earlier different efforts have been made to attain change in sex expression through genetically, environmental and nutritional manipulation. However the use of different inorganic fertilizers at recommended doses becomes important tools in the particular respect. The right combination of inorganic fertilizers at the recommended doses not only alters the sex ratio in cucurbits but also increases the yield to a significant level (Karuppaiah and Kathiravan, 2006) [6]. Of all the above factors, nutrient management forms the essential requirement for establishment of any crop (Singh *et al.*, 2005) [14]. Therefore present investigation was carried out to study the effect of inorganic nutrients at the adequate quantity on yield and quality characters of bitter gourd type "Mithipagal".

Materials and methods
An experiment was carried out at Experimental Farm, Department of Horticulture, Faculty of Agriculture, Annamalai University, Tamil Nadu, India during 2013-2014 to study the effect

of Phosphorus and Potassium on yield and quality characters of bitter gourd ecotype 'Mithipagal' consisting of four levels of Phosphorus (0, 30, 60 and 90 kg ha^{-1}) and three levels of Potassium (0, 40 and 80 kg ha^{-1}) comprised of twelve treatment combinations under Factorial Randomized Block Design (FRBD) with three replications. Nitrogen @ 90 kg ha^{-1} was applied in all treatments as constant dose except the control. Seeds are sown in pits with a spacing of 100 x 75cm. One third of Nitrogen and full doses of Phosphorus and Potassium were applied as basal dose as per the treatment. The remaining doses of Nitrogen were applied on 30 and 45 days after sowing. The data were statistically analyzed using the method suggested by Panse and Sukhatme (1987) [10].

Results and Discussion

Individual effect of Phosphorus on yield attributes

The results revealed that the treatments varied significantly for the yield attributing characters. Among the treatments the maximum number of fruits $plant^{-1}$, fruit weight, fruit length, fruit diameter, fruit volume, fruit yield $plant^{-1}$ and fruit yield ha^{-1} was recorded with the application of P_3 (90 kg ha^{-1}) of 36.53 fruits $plant^{-1}$, 28.65 g $fruit^{-1}$, 3.59 cm, 2.41 cm, 6.44 cm^3, 1.05 kg $plant^{-1}$ and 13.74 t ha^{-1} (Table 1). The increased trend in number of fruits $plant^{-1}$ might be due to the absorption of more nutrients by plants by the higher dose of P which in turn enhances the number of branches and node numbers. It was concurrence with the findings of Parikh and Chandra (1969) [11] in cucumber, who envisaged the enhancement of yield attributes in their respective crops due to the enhancement in applied phosphorus level. Also it was supported by Kumar *et al.* (2004) [8] in ridge gourd and it was opined that the higher levels of phosphorus might have influenced the net assimilation rate and increased the source to sink ratio which might have attributed to the increments in yield characters. Similarly there was significant increase in fruit weight, fruit length, fruit diameter and fruit volume by the increased application of phosphorus. This might be due to the application of higher dose of phosphorus levels which accelerated the source-sink relationship and leads to enhancement of fruit weight, length, diameter and volume. The findings are in line with the results of Singh and Chonkar (1996) [12] who reported that increased dose of phosphorus (60 kg ha^{-1}) fertilization showed significant increase in fruit weight in musk melon. Significantly the highest ascorbic acid content (1.61mg g^{-1}) and TSS (3.02^0 Brix) which received the phosphorus level P_3 (90 kg ha^{-1}) when compared to control (P_0) given in Table1.

Individual effect of Potassium on yield attributes

The results revealed that with the increasing dose of nutrients the yield of the plant increases among the treatments. Among the treatments the maximum number of fruits $plant^{-1}$, fruit weight, fruit length, fruit diameter, fruit volume, fruit yield $plant^{-1}$ and fruit yield ha^{-1} was recorded with the application of K_2 (80 kg ha^{-1}) of 35.01 fruits $plant^{-1}$, 27.41 g $fruit^{-1}$, 3.3.37 cm, 2.38 cm, 5.89 cm^3, 0.97 kg $plant^{-1}$ and 12.47 t ha^{-1} (Table1). The increasing trend of the above yield parameters due to the application of K_2 could be attributed due to its important role in rapid cell division and cell elongation which enhances the production of more number of female flowers and fruits $plant^{-1}$. Further, its role in photosynthesis, energy storage, cell division and enlargement contributed to the increased biomass production and productive source component which is an attributing factor for source-sink relationship (Kumar *et al.* 2004) [8]. It was in conformity with the reports of Khurana *et al.* (1990) [7] in cauliflower, Singh (2000) [13] in hybrid tomato, and Das *et al.* (2005) [3] in vegetable pea who evinced increment in yield attributes due to higher levels of potassium application. The highest yield $plant^{-1}$ and ha^{-1} may be due to the increased trend in number fruits $plant^{-1}$, fruit weight, fruit length, fruit diameter and volume by the application of potassium 80 kg ha^{-1}. Similar increase in yield due to the 'K' application has been reported by Das *et al.* (1987) [2] in pointed gourd and Goswamy and Sharma (1997) [5] in spine gourd. Significantly the highest ascorbic acid content (1.75 mg g^{-1}) and TSS (3.26^0 Brix) which received the phosphorus level K_2 (80 kg ha^{-1}) when compared to control (K_0).

Interaction effect of Phosphorus and Potassium on yield attributes

The significance of variance due to interaction effects of phosphorus and potassium for number of fruits $plant^{-1}$ (38.32), fruit weight (30.10), fruit length (3.85), fruit diameter (2.40), fruit volume (6.78), fruit yield $plant^{-1}$ (1.14 kg) and yield ha^{-1} (15.01 t) were found with the application of P_3K_2 combination. Corroborative results were put forth by Deswald and Patil (1984) [4] in water melon, Mohanty *et al.* (2001) in chilli, Kumar *et al.* (2004) [8] in ridge gourd who envisaged the influence of interaction between P and K in increasing the dry matter production and yield parameters of ridge gourd and opined that the increment in yield parameters due to interaction of P and K might be attributed by the complimentary effect of one over other in the interaction. Significantly the highest ascorbic acid content (1.98 mg g^{-1}) and TSS (3.65^0 Brix) which received the interaction level of P_3K_2 when compared to control (P_0K_0) showed in Table.2.

Table 1: Effect of Phosphorus and Potassium on yield and quality characters of Bitter gourd ecotype 'Mithipagal'

Treatments	Fruit $plant^{-1}$	Fruit weight (g)	Fruit Length (cm)	Fruit diameter (cm)	Fruit volume (cm^3)	Fruit yield $plant^{-1}$ (kg)	Fruit yield ha^{-1} (t)	Ascorbic acid (mg g^{-1})	TSS (^{0} Brix)
Phosphorus levels									
P_0	29.30	22.89	2.50	2.25	4.38	0.66	8.56	1.11	2.24
P_1	31.77	24.82	2.89	2.31	5.02	0.81	10.28	1.40	2.74
P_2	35.66	27.95	3.46	2.42	6.06	1.01	12.93	1.51	2.85
P_3	36.53	28.65	3.59	2.41	6.44	1.05	13.74	1.61	3.02
SED	0.46	0.36	0.15	0.03	0.25	0.02	0.33	0.05	0.09
CD (p = 0.05)	0.95	0.75	0.32	0.05	0.49	0.04	0.68	0.11	0.19
Potassium levels									
K_0	31.59	24.71	2.85	2.31	4.98	0.79	10.21	0.97	2.03
K_1	33.36	26.12	3.11	2.36	5.55	0.89	11.45	1.51	2.85
K_2	35.01	27.41	3.37	2.38	5.89	0.97	12.47	1.75	3.26
SED	0.41	0.31	0.12	0.01	0.16	0.01	0.29	0.04	0.06
CD (p = 0.05)	0.83	0.63	0.23	NS	0.33	0.02	0.62	0.08	0.12

Table 2: Interaction effect of Phosphorus and Potassium on yield and quality characters of Bitter gourd ecotype 'Mithipagal'

Treatments	Fruit plant^{-1}	Fruit weight (g)	Fruit Length (cm)	Fruit diameter (cm)	Fruit volume (cm^3)	Fruit yield plant^{-1} (kg)	Fruit yield ha^{-1} (t)	Ascorbic acid (mg g^{-1})	TSS (^{0} Brix)
T_1: P_0K_0 (0:0 kg ha^{-1})	27.95	21.88	2.28	2.21	3.99	0.58	7.65	0.76	1.76
T_2: P_0K_1 (0:40kg ha^{-1})	29.12	22.77	2.46	2.25	4.33	0.65	8.46	1.23	2.37
T_3: P_0K_2 (0:80 kg ha^{-1})	30.84	24.04	2.76	2.29	4.82	0.76	9.57	1.36	2.61
T_4: P_1K_0 (30:00 kg ha^{-1})	30.37	23.72	2.68	2.28	4.69	0.74	9.35	0.91	2.03
T_5: P_1K_1 (30:40 kg ha^{-1})	31.91	24.93	2.92	2.32	5.04	0.82	10.34	1.50	2.83
T_6: P_1K_2 (30:80 kg ha^{-1})	33.05	25.81	3.09	2.35	5.35	0.89	11.17	*1.81*	*3.36*
T_7: P_2K_0 (60:0 kg ha^{-1})	33.51	26.20	3.15	2.36	5.49	0.91	11.53	*1.05*	*2.07*
T_8: P_2K_1 (60:40 kg ha^{-1})	35.68	27.96	3.45	2.42	6.06	1.02	13.13	1.63	3.06
T_9: P_2K_2 (60:80 kg ha^{-1})	37.79	29.69	3.78	2.48	6.64	1.12	14.15	1.85	3.42
T_{10}: P_3K_0 (90:0 kg ha^{-1})	34.55	27.04	3.32	2.39	5.78	0.96	12.34	1.18	2.28
T_{11}: P_3K_1 (90: 40 kg ha^{-1})	36.74	28.83	3.61	2.45	6.78	1.07	13.89	1.68	3.14
T_{12}: P_3K_2 (90:0 kg ha^{-1})	38.32	30.10	3.85	2.40	6.78	1.14	15.01	1.98	3.65
SED	0.51	0.41	0.26	0.05	0.32	0.03	0.35	0.06	0.11
CD (p = 0.05)	1.02	0.82	0.76	0.15	0.94	0.09	0.71	0.12	0.21

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