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Original Research Article

Yield and Nutrient Uptake by Okra (*Abelmoschus esculentus* L.) as influenced by Integrated Nutrient Management

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A B S T R A C T

A field experiment was carried out to study the effect of integrated nutrient management in okra (*Abelmoschus esculentus* L.) under sub-montane and low hills subtropical zone of Himachal Pradesh at the Experimental Farm of the College of Horticulture and Forestry, Neri, Hamirpur, (HP) during *kharif*2019 in a randomized block design with eleven treatments replicated thrice. The treatments consisted of control (T_1), 100 % RDF (T_2), VC @ 10 t ha^{-1} (T_3), 75 % RDF + VC (T_4), 100 % RDF + VC (T_5), PM @ 10 t ha^{-1} (T_6), 75 % RDF + PM (T_7), 100 % RDF + PM (T_8), FYM @ 10 t ha^{-1} (T_9), 75 % RDF + FYM (T_{10}) and 100 % RDF + FYM (T_{11}).The results revealed that combined application of fertilizers and manures significantly influenced the fruit and stover yield of okra and also resulted in higher nutrient uptake by okra. The treatment comprising of 100 % RDF + poultry manure @ 10 t ha^{-1} (T_8) recorded the highest fruit yield, stover yield and nutrient uptake of okra and was at par with the application of 75 % RDF + poultry manure @ 10 t ha^{-1} (T_7).From these results, it was observed that farmers can save 25 % inorganic fertilizers by integrating inorganic fertilizers with organics and amongst organics poultry manure proved best in attaining maximum yield and higher nutrient removal by okra from the soil. Therefore, 75 % RDF + poultry manure @ 10 t ha^{-1} treatment can be recommended for okra cultivation under sub-montane and low hills subtropical zone of Himachal Pradesh.

Keywords

Okra, Integrated nutrient management, Nutrient uptake, Stover yield, Poultry manure

Introduction

Okra (*Abelmoschus esculentus* L.) is one of the universally known and utilized species of the family Malvaceae and an economically important vegetable crop grown in tropical and sub-tropical parts of the world including India. It has a relatively good nutritional value owing to its richness in protein, carbohydrates, fats, vitamins and minerals besides being abundant in antioxidants like phenolic compounds and flavonoid derivatives. Okra is cultivated nearly in all agro-ecological zones throughout the country occupying an area of about 509.02 thousand hectares with a production of around 6094.94 thousand metric tonnes (Anonymous, 2018). In the era of crop diversification, vegetable cultivation in Himachal Pradesh is gaining significant importance on account of favorable agro – climatic conditions and okra has emerged out as one of important vegetable crop of the state. Presently, in the state, okra is being grown in an area of about

3.39 thousand hectares with an annual production of 45.98 thousand metric tonnes (Anonymous, 2018). But, being a short duration crop, yield and uptake by okra are largely influenced by nutrient management practices. To further improve it's productivity, balanced plant nutrition has an imminent role, for which use of organics along with inorganic sources of nutrition can be an option.

The fertilizers have played a prominent role in increasing the productivity of crops in the country. However, the continuous and imbalanced fertilization may lead to substantial deterioration of soil health and had adversely affected human health besides creating serious concerns of environmental pollution by their prolonged and over usage. Organic manures improve soil physical, chemical and biological properties and thus enhance crop productivity *vis-à-vis* maintain soil health. In addition to this, it also help in improving the use efficiency of inorganic fertilizers (Singh and Biswas, 2000) and reduces nutrient losses, synchronize nutrient availability and uptake leading to sustainable crop production due to its slow release nature (Acharya and Mandal, 2002). Further, organic manures are also devoid of harmful residues and improve crop quality. However, the exclusive use of organic sources could not meet total nutrients required to achieve the target of agricultural production owing to it's availability in the country at present. Given, the organic resources constraint, the use of organic is supplementary rather complimentary. Neither organic manures nor chemical fertilizer alone can achieve the yield sustainably. Their integrated use may help in improving productivity, nutrient uptake by the crop and ultimately the quality of the produce. Integrated nutrient management is in fact most important component of the production technology to sustain soil fertility and crop productivity in the future. The advantage of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately (Palaniappan and Annadurai, 2007).

Therefore, for increasing the productivity of okra further integrated nutrient management can be a better option over alone use of organics and inorganics. With this background, an attempt was made to develop integrated nutrient supply package for economical productivity of okra in terms of yield and nutrient uptake.

Materials and Methods

A field experiment was carried out to study the effect of integrated nutrient management in okra (*Abelmoschus esculentus* L.) under sub-montane and low hills subtropical zone of Himachal Pradesh at the Experimental Farm of the College of Horticulture and Forestry, Neri, Hamirpur, (HP) during *kharif*2019.The experimental farm is located at 31^{o} 41′ 47.6″ N latitude and 76^{o} 28′ 06.3″ E longitude and lies at an elevation of 650 meters above mean sea level under subtropical agro-climatic zone of Himachal Pradesh. The experiment was conducted following the standard recommended cultural practices for the cultivation of okra (cv.P-8) and consisted of eleven treatments which were replicated thrice in a complete randomized block design (RBD). The treatments consisted of control (T_1), 100 % RDF (T_2), vermicompost @ 10 t ha^{-1} (T_3), 75 % RDF + vermicompost (T_4), 100 % RDF + vermicompost (T_5), Poultry manure @ 10 t ha^{-1} (T_6), 75 % RDF + Poultry manure (T_7), 100 % RDF + Poultry manure (T_8), FYM @ 10 t ha^{-1} (T_9), 75 % RDF + FYM (T_{10}) and 100 % RDF + FYM (T_{11}). Fruit yields (kg plot^{-1}) of each respective plots were recorded in each subsequent picking of the fruits/pods and was then transformed into yield per hectare (q ha^{-1}). The stover yield of each plot was also recorded to obtain the dry matter content of okra crop after the final picking at the end of season. The stover yield per plot (kg) was also transformed into yield per hectare (q ha^{-1}).Samples of fruit and stover were collected, first air dried, then dried in oven for 3-4 days at 60°C till constant weight. The dried samples were then grounded in a steel grinder for further determining N, P, K, S, Ca, Mg, Fe, Mn, Zn and Cu content to work out the nutrient uptake. For determining the total nitrogen content, grounded plant and fruit samples were digested with concentrated H_2SO_4 using digestion mixture and total nitrogen was determined by Micro Kjeldahl method (A.O.A.C., 1970). For determining the P, K, S, Ca, Mg, Fe, Mn, Zn and Cu, separate digestions were carried out for both fruits and stover samples with diacid mixture of HNO_3 and $HClO_4$ in the ratio of 9:4 and then respective extracts were made to a definite volume. Total phosphorus was determined by vanadomolybdate phosphoric acid yellow colour method (Jackson, 1973).S- 935/ microprocessor flame photometer was used for the determination of potassium content from the derived extracts as per the method proposed by Chapman and Brown (1950). Sulphur was determined by using Spectronic 200 spectrophotometer as per the turbidimetric method outlined by Chesnin and Yien Calcium was also determined by using S- 935/ microprocessor flame photometer from the extract obtained by digestion with diacid mixture (Black, 1965).Magnesium was determined on atomic absorption spectrophotometer (Motras Scientific AAS plus) from the obtained extracts of fruit and stover samples (Jackson, 1973).Fe, Cu, Zn and Mg were analysed on atomic absorption spectrophotometer (Motras Scientific AAS plus) from the extracts obtained with digestion (Jackson, 1973). The nutrient uptake was finally calculated by multiplying per cent concentration of a particular nutrient with fruit and stover yield on dry weight basis. The uptake of the nutrients obtained in respect of fruit and stover yield was totaled in order to compute the total amount of nutrients removed by okra.

Nutrient uptake (kg ha^{-1}) = Nutrient content (%) x yield (q ha^{-1})

Total uptake = uptake by fruit + uptake by stover

Results and Discussion

Fruit yield of okra

It is evident from the data (Table 1) that fruit yield of okra was significantly affected by the integrated nutrient management in okra during *kharif* 2019. The fruit yield of okra varied from a minimum of 84.10 q ha^{-1} in control (T_1) to a maximum of 156.14 q ha^{-1} in plots receiving 100 per cent RDF through chemical fertilizers along with poultry manure @ 10 t ha^{-1} (T_8). On comparing the treatments consisting of poultry manure ($T_6$to T_8), the increase in fruit yield was highest under treatment applied with 100 per cent RDF with poultry manure @ 10 t ha^{-1} (T_8) which was at par with 75 per cent RDF with poultry manure @ 10 t ha^{-1} (T_7) but was superior over alone application of poultry manure (T_6) (Fig. 1).

Stover yield of okra

The data pertaining to stover yield of okra have been presented in Table 1. Like fruit yield, highest stover yield of okra (36.74 q ha^{-1}) was also recorded in plots receiving 100 per cent RDF along with poultry manure @ 10 t ha^{-1} (T_8) while least (20.86 q ha^{-1}) was observed in control (T_1). All the treatments recorded significantly higher stover yield over control (T_1). A significant increase of 52.73 per cent in the stover yield of okra was recorded with the application of 100 per cent RDF through chemical fertilizers alone (T_2) over control (T_1). Amongst different organics, poultry manure was found superior and highest increase in stover yield of okra was recorded in the treatment receiving poultry manure over vermicompost and FYM, the differences however, were not significant.

Nutrient uptake by okra

Conjoint application of fertilizers and organic manures significantly influenced the total nutrient uptake by okra crop (N, P, K, S, Ca, Mg, S, Fe, Mn, Cu and Zn) and followed almost similar trend as that of yield. Nutrient uptake was significantly influenced by the application of chemical fertilizers alone or in combination with organic manures over control (T_1). Highest total uptake of all the nutrients (N, P, K, S, Ca, Mg, S, Fe, Mn, Cu and Zn) was found in plots receiving 100 per cent RDF along with 10 t ha^{-1}poultry manure (T_8).

Nutrient uptake of available nutrients (N, P, K & S)

The data pertaining to the effect of integrated nutrient management on available nutrients present in the soil (N, P, K& S) uptake by okra have been presented in Table 2. The total N uptake in okra varied from 57.52 kg ha^{-1} in T_1 (control) to 124.03 kg ha^{-1} in T_8 (100 per cent RDF + poultry manure @ 10 t ha^{-1}). Application of chemical fertilizers alone or in conjunction with organic manures resulted in a significant increase in total N uptake by okra over control (T_1). Application of 100 per cent RDF with poultry manure @ 10 t ha^{-1} (T_8) increased the nitrogen uptake by 28.86 per cent over 100 per cent RDF alone (T_2) and was at par with 75 per cent RDF with poultry manure @ 10 t ha^{-1} (T_7) however, it was significantly superior over alone application of poultry manure (T_6).

Total P uptake by okra varied from 17.53 kg ha^{-1} in control (T_1) to 46.36 kg ha^{-1} in 100 per cent RDF + poultry manure @ 10 t ha^{-1} (T_8) treatment. Control plots where no fertilizers or organic manures were supplied recorded lowest total P uptake by okra. Application of 100 per cent RDF alone (T_2) registered an increase of 75.69 per cent over control (T_1). Vermicompost, poultry manure and FYM when applied alone or along with 75 and 100 percent RDF significantly increased the P uptake by okra over control. Amongst the treatments consisting of poultry manure (T_6 to T_8), highest P uptake was observed under treatment applied with 100 per cent RDF with poultry manure @ 10 t ha^{-1} (T_8) which was found to be superior over 75 per cent RDF with poultry manure @ 10 t ha^{-1} (T_7) and alone application of poultry manure (T_6).

Like N and P, total uptake of K was also affected significantly under different treatments (Table 2). Control treatment (T_1) was significantly inferior over rest of the treatments recording the lowest value of total K uptake by okra stover. On comparing the treatments receiving poultry manure (T_6 to T_8), highest K uptake was observed in treatment applied with 100 per cent RDF + poultry manure @ 10 t ha^{-1} (T_8) which was statistically superior over 75 per cent RDF + poultry manure @ 10 t ha^{-1} (T_7) and alone application of poultry manure (T_6) unlike vermicompost and FYM, where the graded doses (75 & 100 %) of fertilizers along with organics were at par with each other and superior to their sole use.

The total S uptake by okra ranged from 2.93 kg ha^{-1} in control (T_1) to 7.61 kg ha^{-1} in 100 per cent RDF + poultry manure @ 10 t ha^{-1}

(T_8). Recommended doses of fertilizers (T_2) resulted in an increase of 77.81 per cent of total S uptake over control (T_1).

Vermicompost, poultry manure and FYM when applied alone (T_3, T_6 and T_9, respectively) significantly increased the total S uptake by okra to an extent of 49.14, 59.72 and 40.95 per cent, respectively over control (T_1). Total sulphur uptake in treatments comprising of vermicompost and FYM was also alike the treatments comprising of poultry manure.

Nutrient uptake of secondary nutrients (Ca & Mg)

A critical examination of the data given in Table 3 revealed that the range of variation of total Ca uptake by okra was found from 7.89 kg ha^{-1} under control (T_1) to 22.26 kg ha^{-1} under 100 per cent RDF + poultry manure @ 10 t ha^{-1} (T_8). Application of chemical fertilizers alone (T_2) registered an increase of 89.22 per cent over control(T_1). Highest significant increase of total Ca uptake by okra was recorded in 100 per cent RDF + poultry manure @ 10 t ha^{-1} (T_8) followed by 100 per cent RDF + vermicompost @ 10 t ha^{-1} (T_5) and the increase was to the tune of 49.09 and 39.91 per cent, respectively over 100 per cent RDF alone (T_2).

Further examination of the data revealed that total Mg removal by okra crop ranged between 5.12 and 10.59 kg ha^{-1}. The highest value of total Mg uptake by okra was recorded with the application of 100 per cent RDF + poultry manure @ 10 t ha^{-1} (T_8) and least in control (T_1).

Recommended doses of fertilizers when applied with poultry manure @ 10 t ha^{-1} (T_8) increased the Mg uptake by 28.36 per cent over 100 per cent RDF alone and was at par with 75 per cent RDF applied with poultry manure @ 10 t ha^{-1} (T_7) however, it was found significantly superior over the alone application of poultry manure (T_6). Results obtained in vermicompost and FYM treated plots were also similar to that of poultry manure treated plots in view of the total magnesium uptake by okra crop.

Nutrient uptake of micro-nutrients (Fe, Cu, Zn, Mn)

It is evident from the data (Table 4) that the lowest Fe uptake (1089.06 g ha^{-1}) was recorded in control (T_1) and the highest (2425.94 g ha^{-1}) was recorded in 100 per cent RDF + poultry manure @ 10 t ha^{-1} (T_8), followed by 100 per cent RDF + vermicompost @ 10 t ha^{-1} (2296.43 g ha^{-1}) (T_5).

The treatments consisting of 75 per cent or 100 per cent RDF + organics @ 10 t ha^{-1} were at par with each other. Regarding the total Cu uptake by okra crop, the values ranged between 101.18 g ha^{-1} in control (T_1) and 302.38 g ha^{-1} in 100 per cent RDF + poultry manure @ 10 t ha^{-1}(T_8). Control treatment (T_1) was significantly inferior over rest of the treatments recording the lowest value of total Cu uptake by okra.

On comparing the treatments consisting of poultry manure, the highest increase in total Cu uptake (65.09 %) was observed under the treatment applied with 100 per cent RDF with poultry manure @ 10 t ha^{-1} (T_8) over 100 per cent RDF alone which was statistically superior over 75 per cent RDF + poultry manure @ 10 t ha^{-1} (T_7) and alone application of poultry manure (T_6). Similar trend was observed under vermicompost and FYM treatments as in case of poultry manure. The data presented in table 4 also depicted that total Zn uptake by okra ranged from 156.45 in control (T_1) to 495.14 g ha^{-1} under 100 per cent RDF + poultry manure @ 10 t ha^{-1} (T_8).

Table.1 Effect of integrated nutrient management on fruit and stover yield of okra

Treatment		Fruit yield (q ha^{-1})	Stover yield (q ha^{-1})
T_1	Control	84.10	20.86
T_2	100 % RDF	125.15	31.86
T_3	Vermicompost @ 10 t ha^{-1}	114.06	28.80
T_4	75 % RDF + Vermicompost @ 10 t ha^{-1}	147.22	31.98
T_5	100 % RDF + Vermicompost @ 10 t ha^{-1}	150.33	36.10
T_6	Poultry manure @ 10 t ha^{-1}	118.04	30.18
T_7	75 % RDF + Poultry manure @ 10 t ha^{-1}	149.82	32.61
T_8	100 % RDF + Poultry manure @ 10 t ha^{-1}	156.14	36.74
T_9	FYM @ 10 t ha^{-1}	113.64	27.85
T_{10}	75 % RDF + FYM @ 10 t ha^{-1}	138.58	32.29
T_{11}	100 % RDF + FYM @ 10 t ha^{-1}	147.77	33.56
CD (P=0.05)		10.52	6.01

Table.2 Effect of integrated nutrient management on available nutrients (N, P, K & S)

Treatment		Total uptake (kg ha^{-1})			
		N	**P**	**K**	**S**
T_1	Control	57.52	17.53	25.34	2.93
T_2	100 % RDF	96.25	30.80	48.58	5.21
T_3	Vermicompost @ 10 t ha^{-1}	81.76	25.37	38.48	4.37
T_4	75 % RDF + Vermicompost @ 10 t ha^{-1}	105.67	35.70	54.27	6.14
T_5	100 % RDF + Vermicompost @ 10 t ha^{-1}	118.49	40.37	61.26	7.04
T_6	Poultry manure @ 10 t ha^{-1}	86.52	27.85	44.49	4.68
T_7	75 % RDF + Poultry manure @ 10 t ha^{-1}	109.42	39.82	58.84	6.67
T_8	100 % RDF + Poultry manure @ 10 t ha^{-1}	124.03	46.36	67.11	7.61
T_9	FYM @ 10 t ha^{-1}	78.74	24.47	39.10	4.13
T_{10}	75 % RDF + FYM @ 10 t ha^{-1}	102.48	34.42	53.43	5.78
T_{11}	100 % RDF + FYM @ 10 t ha^{-1}	110.91	38.84	56.93	6.48
CD (P=0.05)		*14.88*	*4.57*	*8.14*	*0.60*

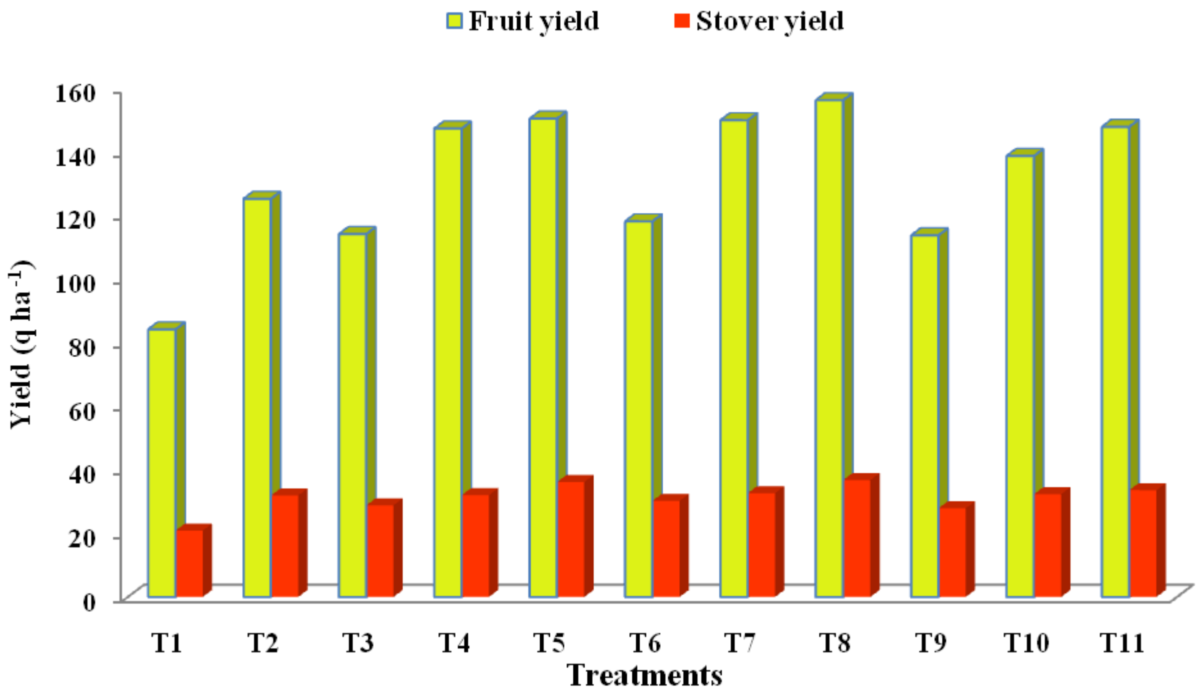
Table.3 Effect of integrated nutrient management on secondary nutrients (Ca & Mg)

Treatment		Total uptake (kg ha^{-1})	
		Ca	Mg
T_1	Control	2.49	5.41
T_2	100 % RDF	4.69	10.24
T_3	Vermicompost @ 10 t ha^{-1}	3.74	8.15
T_4	75 % RDF + Vermicompost @ 10 t ha^{-1}	6.23	11.82
T_5	100 % RDF + Vermicompost @ 10 t ha^{-1}	6.77	14.12
T_6	Poultry manure @ 10 t ha^{-1}	4.28	9.27
T_7	75 % RDF + Poultry manure @ 10 t ha^{-1}	6.44	12.36
T_8	100 % RDF + Poultry manure @ 10 t ha^{-1}	7.28	14.98
T_9	FYM @ 10 t ha^{-1}	3.71	7.66
T_{10}	75 % RDF + FYM @ 10 t ha^{-1}	5.71	11.07
T_{11}	100 % RDF + FYM @ 10 t ha^{-1}	6.57	12.52
CD (P=0.05)		*0.69*	*2.51*

Table.4 Effect of integrated nutrient management on micro-nutrients (Fe, Cu, Zn & Mn)

Treatment		Total uptake (g ha^{-1})			
		Fe	Cu	Zn	Mn
T_1	Control	1089.06	101.18	156.45	108.62
T_2	100 % RDF	1844.43	183.15	319.70	287.90
T_3	Vermicompost @ 10 t ha^{-1}	1598.18	149.05	242.20	200.40
T_4	75 % RDF + Vermicompost @ 10 t ha^{-1}	2065.49	238.56	396.11	367.23
T_5	100 % RDF + Vermicompost @ 10 t ha^{-1}	2296.43	275.19	453.57	418.57
T_6	Poultry manure @ 10 t ha^{-1}	1706.83	162.54	276.08	224.93
T_7	75 % RDF + Poultry manure @ 10 t ha^{-1}	2172.90	257.33	430.46	381.64
T_8	100 % RDF + Poultry manure @ 10 t ha^{-1}	2425.94	302.38	495.14	444.84
T_9	FYM @ 10 t ha^{-1}	1491.78	142.68	227.12	186.75
T_{10}	75 % RDF + FYM @ 10 t ha^{-1}	2004.23	214.04	370.35	352.88
T_{11}	100 % RDF + FYM @ 10 t ha^{-1}	2155.96	261.54	413.58	390.41
CD (P=0.05)		256.26	17.80	37.48	42.57

Fig.1 Figure showing effect of INM on fruit and stover yield of okra



The treatments comprising of 100 per cent RDF + poultry manure (T_8) was found to be significantly superior over other treatments (T_2, T_5, T_{11}). Amongst the treatments receiving graded doses of fertilizers with organic manures, 100 per cent RDF rate was found significantly superior over 75 per cent RDF rate when combined with respective organics. The total uptake of Mn by okra crop varied from 108.62 to 444.84 g ha^{-1}. Control (T_1) recorded the lowest values of total Mn uptake by okra crop while highest was registered in treatment receiving 100 per cent RDF + poultry manure @ 10 t ha^{-1} (T_8). Alone application of organic manures *viz*., vermicompost, poultry manure and FYM was found inferior over their integrated use with chemical fertilizers. Manganese uptake by okra crop in treatments receiving 100 per cent RDF along with various organic manures *viz*., vermicompost, FYM and poultry manure (T_5,T_8,T_{11}) was statistically superior over their respective use with 75 per cent RDF (T_4 and T_7) except T_{10} where FYM was applied with 75 per cent RDF which was at par with T_{11}.

From these results, it concluded that there was a significant increase in fruit and stover of okra due to the integrated use of organic manures and inorganic fertilizers. For attaining maximum yield and higher uptake by okra, a combination of 75 per cent RDF + poultry manure @ 10 t ha^{-1} could be an appropriate integrated nutrient supply package for okra. Therefore, 75 per cent RDF + poultry manure @ 10 t ha^{-1} treatment can be recommended for okra cultivation under sub-montane and low hills subtropical zone of Himachal Pradesh.

A significant increase fruit with stover yield with integrated use of chemical fertilizers alone or in conjunction with organic manures may be due to the involvement of organic manure which contains mainly macro and micro nutrients as well as growth promoting substances which induced better plant growth. Increased of okra with integration of fertilizers and organics might be attributed to the balanced and sufficient supply of nutrients from organics and chemical fertilizers, improved physical, chemical and biological properties of the soil which might have augmented root system and promoted higher nutrient and water absorption, thus better plant growth which led to higher crop productivity. These observations are in the conformity with the findings of Bharthy *et al.,* (2017), Dhiman *et al.,* (2018) and Singh and Tiwari (2019).

Integration of fertilizers and manures recorded higher uptake of nutrients which might be attributed to the improved synchronization between release of nutrients and their uptake in plants. Minimum nutrient uptake in control might be attributed to lower yield obtained in these plots. In rest of the treatments, the uptake of nutrients increased due to the increased availability of nutrients with the application of organics and inorganic fertilizers either alone or in conjunction which accelerated the physiological and metabolic activities. Furthermore, application of organics might have increased the availability of native micronutrients through chelation (Gupta,1995), leading to higher biomass production and higher uptake. Amongst organic manures, poultry manure was found superior which might be due to the fact that it added higher amount of nutrients in the soil, hence higher yields and uptakes were observed with poultry manure treated plots.

References

A.O.A.C., 1970. *Official and tentative methods of analysis*. Association of official Analytical Chemists. William Star Wetglad, Washington.

Acharya, C. L., and Mandal, K. G. 2002. Integrated plant nutrient supply in vegetable crops *In Compendium: Recent advances in vegetable production technology, Proceedings of Winter School,* held at Indian Institute of Vegetable Research, Varanasi, India, 3-23 December, 2002, Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh. pp. 79-104.

Anonymous., 2018. Horticultural Statistics at a Glance. National Horticulture Board http:// www. nhb.gov.in (11:05 AM, 21st June 2020)

Bharthy, R. B., M. Sankaran, and Subramani, T. 2017. Effect of integrated nutrient management on nutrient uptake and yield of okra [*Abelmoschus esculentus* (L.) Moench] under Islands conditions. *Advanced Research Journal of Crop Improvement.*8: 24-30.

Black, C.A., 1965. *Methods of Soil Analysis. Part II.* American Society of Agronomy, Madison, Wisconsin, USA. 572p.

Chapman, H.D., and Brown, S.M. 1950. Analysis of organics leaves for diagnosing nutrient status with reference to potassium. *Hilgardia.*19: 501-540.

Chesnin, L., and Yien, C.H. 1950. Turbidimetric determination of available sulphate. *Soil Science Society America Proceedings.*15: 149-151.

Dhiman, S., S. P. Dixit and Sepehya, S. 2018. Pea-okra yield and soil properties under integrated nutrient management in a north-western Himalayan soil. *International Journal of Agriculture Sciences.*10: 6076-80.

Gupta, V. K., S. P. Gupta, R. Kala, B. S. Potalia and Kaushik, R.D. 1995. Twenty five years of micronutrients research in soils and crops of Haryana. Technical Bulletin.

Department of Soil Science, CCSHAU, Hisar.

Jackson, M. L., 1973. *Soil Chemical Analysis*. Prentice Hall Inc. Englewood Cliffs, New Jersey, USA. 498p.

Palaniappan, S. P., and Annadurai, K. 2007. *Organic Farming: Theory and Practices*. Scientific Publishers, Jodhpur. pp 169.

Singh, G. B., and Biswas, P. P. 2000. Balanced and integrated nutrient management for sustainable crop production: Limitations and future strategies. *Fertilizer News.* 45(5): 55-60.

Singh, V. B., and Tiwari, A. K. 2019. Effect of integrated nutrient management (INM) on physico-chemical properties of soil, available content and nutrient uptake by okra (*Abelmoschus esculentus*). *International Journal of Current Microbiology and Applied Sciences.* 8: 130-37.