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Growth, quality, yield and available nutrient status after harvest of summer sesamum (*Sesamum indicum* L.) in loamy sand as influence by integrated nutrient management

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Abstract
A filed experiment entitled a “growth, quality, yield and available nutrient status after harvest of summer sesamum (*Sesamum indicum* L.) in loamy sand as influence by integrated nutrient management” was conducted at Agronomy Instructional Farm, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar during summer, 2018. The experiment consisted of total ten treatments of integrated nutrient management were tested in randomized block design with three replications. The soil of experimental field was loamy sand in texture, low in organic carbon (0.18%), available nitrogen (140.31 kg ha^{-1}) and sulphur (9.80 mg kg^{-1}); medium in available phosphorus (42.00 kg ha^{-1}) and potash (204.02 kg ha^{-1}) and slightly alkaline (pH 7.62) in reaction. The results revealed that nutrient management treatments showed significant influence on growth, yield attributes, yield and quality parameters of sesamum. The highest plant height (77.54 cm), number of branches per plant (4.02), number of capsules per plant (74.30), test weight (3.57 g), seed yield (978 kg ha^{-1}) and stalk yield (2368 kg ha^{-1}) were recorded under treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter*. Based on one year experimentation, it is concluded that integrated application of 50% RDF (50: 25: 00 NPK kg ha^{-1}) along with 5 t FYM ha^{-1} + PSB + *Azotobacter* gave higher seed yield of summer sesame grown under loamy sand of North Gujarat.

Keywords: Sesamum, INM, yield, nutrient status

Introduction
Oilseed crops play the second most important role in the Indian agricultural economy next to food grains in terms of area and production. The Indian climate is suitable for the cultivation of oilseed crops; therefore, large varieties of oilseeds are cultivated in our country. Among the oilseed crops, sesamum (*Sesamum indicum* L.) is well known and is one of the oldest crops in the world. It is known as 'The queen of oils' due to its high nutritional, medicinal, cosmetic and cooking qualities. Oleic and linoleic acids are the predominant fatty acids of sesamum oil that have many dietary and health benefits for humans. India ranks first in area, production and export of sesamum in the world. Sesamum ranks third in terms of total oilseed area and fourth in terms of total oilseed production in India. It is one of the important oilseed crops in West Bengal and mainly grown in marginal land with minimum care. The area, production and productivity of sesamum are higher in summer season than those of post-kharif and kharif seasons. Lower productivity of sesamum is due to the use of sub-optimal rate of fertilizer, poor management and cultivation of sesamum in marginal and sub-marginal lands where deficiency of macronutrients such as nitrogen, phosphorus, potassium and micronutrient is predominant.

Sesamum is cultivated in an area of 19.53 lakh hectares in India with an annual production of 8.50 lakh tonnes and productivity of 463 kg ha^{-1}. Gujarat is the largest producer of sesamum followed by West Bengal, Maharashtra, Rajasthan, Tamil Nadu and Karnataka. These six states account about for 64 per cent of the total area and 78 per cent of the production of sesamum in the country. Kheda, Bhavnagar Sabarkantha, Amerli and Kutch districts are main producer of sesamum. The estimated area of sesamum in Gujarat is 1.64 lakh hectares, with a production of 0.64 lakh tonnes and productivity is 390 kg ha^{-1}.

Integration of organic and inorganic fertilizer materials in sesamum has been found to be promising not only in maintaining higher productivity and for providing stability in crop production, besides improving soil physical conditions (Deshmukh *et al*., 2002 and Verma *et al*., 2012[a]) [2, 21]. Integrated use of chemical and organic fertilizer in balanced proportion for sustainable production of sesamum was emphasized by Duhoon *et al*. 2002 [2, 4].

Farmyard manure (FYM) has been advocated as good organic manure for use the integrated nutrient management programme for field crops. Higher seed yield of sesamum can be obtained by integrated use of fertilizer along with FYM (Purushottam, 2005 and Jaishankar and Wahab, 2005) [13, 6].
Vermicompost is a potential organic input contains beneficial microorganism's major (NPK) and micro nutrients, enzymes and hormones. It is a recent innovation in composting technology. Use of vermicompost has been advocated in integrated nutrient management system for field crops. Addition of vermicompost improves the chemical and biological properties of soil and thereby improves its fertility. The application of vermicompost not only adds plant nutrients (both macro and micro) and growth regulators but also increases soil water retention, microbial population, humic substances in the soil, mineralization and release of nutrients. Besides these, vermicompost also improves soil aeration, reduces soil erosion, evaporation losses of water, accelerates the process of humification and stimulates the microbial activity, destruction of pathogens and detoxification of pollutants in soil (Manna and Biswas, 1996) [7]. *Azotobacter* is one of the most important non-symbiotic N-fixing micro organisms and considered to be very important for fixation of N in non-leguminous plants. *Azotobacter* has been promising to improve nitrogen status of soil and crop yield due to their capacity to fix atmospheric nitrogen. In addition, it also secretes growth promoting substances like gibberellins, indole acetic acid etc.

Materials and Methods

A field experiment was conducted on Plot No. C-5 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat). The geographical situation of the experimental site is located at 72° 19' East longitude and 24° 19' North latitude at 154.52 meters above the mean sea level. The climate of this region is sub-tropical monsoon type and falls under semi arid region. In general, monsoon is warm and moderately humid, winter is fairly cold and dry, while summer is largely hot and dry. Generally, monsoon commences in the last week of June and retreats by the middle of September and most of the precipitation is received from the south-west monsoon, concentrating in the months of July and August. The seasonal average rainfall (1981-2017) is about 626.44 mm in about 25 rainy days and seasonal rainfall of 2017 was about 589.6 mm in about 32 rainy days.
The experimental field had an even topography with a gentle slope having good drainage. The soil samples were taken randomly from different spots to a depth of 0-15 cm before layout of experiment and composite soil sample was prepared and analysed it for physical as well as chemical properties of soil. The values obtained and the methods used for the determination are presented in Table 1.
The field experiment was conducted during summer, 2018 consisted of total ten treatments of integrated nutrient management *viz*., T_1 - 100% RDF (50 + 25 + 00 kg NPK ha^{-1}), T_2 - 100% RDF + PSB + *Azotobacter*, T_3 - 50% RDF + 5.0 t FYM ha^{-1}, T_4 - 75% RDF + 2.5 t FYM ha^{-1}, T_5 - 50% RDF + 2.0 t vermicompost ha^{-1}, T_6 - 75% RDF + 1.0 t vermicompost ha^{-1}, T_7 - 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter*, T_8 - 75% RDF + 2.5 t FYM ha^{-1} + PSB + *Azotobacter*, T_9 - 50% RDF + 2.0 t vermicompost ha^{-1} + PSB + *Azotobacter*, T_{10} - 75% RDF + 1.0 t vermicompost ha^{-1} + PSB + *Azotobacter* were tested in randomized block design with three replications. The statistical analysis of the data collected for different parameters were carried out by the procedure as described by Panse and Sukhatme (1985) [11] using computer system at the Computer Centre, Department of Agricultural Statistics, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar. The value of calculated 'F' was worked out and compared with the value of table "F" at 5 per cent level of significance. The standard error of Mean (S.Em.), Critical Difference at 5 per cent, Co-efficient of variation were worked out and are presented in respective tables.

Results and Discussions

Growth, yield and yield attributes

The data presented in Table 2 indicated that the application of various integrated nutrient management treatments did not have significant influence on plant height of summer sesamum, but numerically higher (75.74 cm) plant height was obtained under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter* (T_7). The minimum plant height (61.17 cm) was recorded with an application of 100 =% RDF only (T_1). The mean data of number of branches per plant recorded at harvest as influenced by various nutrient management treatments are presented in Table 2. An application of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter* (T_7) recorded significantly maximum number of branches per plant (4.02) over rest of the treatments except the treatments T_8, T_9 and T_{10}. Minimum number of branches per plant (3.06) of sesamum crop at harvest was recorded with the treatment of 100 =% RDF alone (T_1). This might be due to the integrated application of nutrients through inorganic and organic sources provided balanced nutrition to the crop and improved the physical, chemical and biological properties of soil and maintain the nutrient supply system throughout the plant growth stages which in turn increased cell division and cell elongation which promoted vegetative growth and ultimately increased number of branches per plant. These results are in close conformity with the findings of Subramaniyan and Arulmozhi (1999) [17], Pathak *et al*. (2002) [12] and Singh *et al*. (2006[a]) [14].
The data presented in Table 2 revealed that significantly the highest number of capsules (74.30) per plant was obtained under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter* (T_7) over rest of the treatments, but it remained at par with T_8, T_9, T_{10} and T_3 treatments. The lowest number of capsules (54.76 per plant) was obtained when only 100% RDF (T_1) was applied to the crop. The marked improvement in number of capsules per plant in sesamum under the application of various nutrients in integrated manner seems to be an account of its profound influence in enhancing branching which might have facilitated greater flowers formation, later on adequate supply of metabolites and nutrients matching to the demands of reproductive structures for their growth and development which ultimately led to increase in number of capsules in sesamum plant. Similar results were observed by Mousavi *et al.* (2005) [9]. The data given in Table 2 revealed that the test weight of sesamum did not differ significantly under the influence of various integrated nutrient management treatments, but numerically the higher test weight (3.57 g) was obtained under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + Azotobacter (T_7).
An appraisal of data presented in Table 2 revealed that differences in seed yield due to different nutrient management treatments were found significant. The application of 50%

RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter* (T_7) produced significantly the highest seed yield (978 kg ha^{-1}) of sesamum over rest of the treatments, but remained at par with T_8, T_9 and T_{10} treatments. Application of only 100% RDF (T_1) to sesamum crop gave the lowest seed yield (780 kg ha^{-1}). The highest seed yield of sesamum was obtained due to higher and balanced supply of nutrients through organic and inorganic sources of nutrients throughout the lifecycle of plants resulted in improvement in tissue differentiation from somatic to reproductive stage helped in the more flowers and number of capsules per plant which resulted in increase in seed yield of sesamum. These findings in line of the findings of Tiwari *et al.* (1995) [19], Palaniappan *et al.* (1999) [10], Singh *et al.* (2001) [15] and Duhoon *et al.* (2004).

Data presented in Table 2 explicit that significantly the highest stalk yield (2368 kg ha^{-1}) was obtained under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobactor* (T_7) over rest of the treatments but it remained at par with T_8, T_9, T_{10}, T_3 and T_4 treatments. The lowest stalk yield (1921 kg ha^{-1}) was noted under the treatment of 100% RDF (T_1) only to sesamum crop. Increase in stalk yield can be ascribed due to overall improvement in plant organs (plant height and branches) associated with faster and uniform vegetative growth of the crop under the influence of INM treatments as compared to chemical fertilizers (only through inorganic sources) resulted in increase in stalk yield. Similar results were observed by Ghosh (2000) [5] and Sujathamma *et al.* (2003) [18].

Oil content and oil yield

The data given in Table 2 indicated that differences in oil content in sesamum seed was found non-significant under the application of various INM treatments, but numerically higher oil content (49.25%) in sesamum seeds was recorded by the application of 50% RDF + 5.0 t FYM ha^{-1} + PSB + Azotobactor (T_7) and minimum (47.53%) oil content was noted under 100% RDF. The highest oil yield (481 kg ha^{-1}) was obtained under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + Azotobactor (T_7) which was significantly superior over rest of the treatments but remained at par with the treatments T_8, T_9 and T_{10}. The lowest oil yield (371 kg ha^{-1}) was obtained when only 100% RDF (T_1) was applied to the crop. The increment in oil yield might be due to better availability of desired and required nutrients in the crop root zone resulting from its solubilization caused by the organic acids produced from the decaying of organic matter and FYM which also improved the physico chemical properties and CEC of soil ultimately reflected into higher oil content and oil yield. The results are in close agreement with the observations of Tripathy and Bastia (2012) [20].

Physical and chemical properties of soil after harvest of crop

Data presented in Table 3 explicit that organic carbon in soil after harvest of crop did not differ significantly by the application of various nutrients management treatments. However, the maximum value of organic carbon content in soil (0.197%) was registered under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobactor* (T_7). EC of the soil after harvest of crop did not differe significantly due to the application of various nutrient treatments. However, the maximum value of EC in soil (0.130) was registered under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + Azotobactor (T_7). Data pertaining to pH of the soil after harvest of crop did not differed significantly due to the application of various integrated nutrients management treatments after harvest of crop. However, the minimum value of pH in soil (7.44) was registered under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + Azotobactor (T_7). The maximum value of pH in soil (7.73) was recorded under 100% RDF alone (T_1).

The data given in Table 3 revealed that the application of integrated nutrient management treatments significantly influenced the available nitrogen content in soil after harvest of the crop. Significantly the highest available soil N (151.78 kg ha^{-1}) after harvest of the crop was found under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + Azotobactor (T_7) and lowest available soil nitrogen (139.87 kg ha^{-1}) was found under the application of 100% RDF alone (T_1); but, it was at par with T_3, T_4 and T_8 treatments. This might be due to addition of FYM along with inorganic fertilizers created favourable condition for microbial and chemical activity, improved water retention capacity and CEC of soil resulted in prolific root development which added organic matter to the soil and release organic complex substances (chelating agents) during the decomposition of organic matter which in turn formation of more stable available nutrients. Similar findings were also reported by Basu *et al.* (2006) [1].

The data given in Table 3 revealed that nutrient management treatments did not show significant effect on the available phosphorus in soil after harvest of the crop but numerically higher available phosphorus in soil after harvest of crop (46.80 kg ha^{-1}) was obtained with an application of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobactor* (T_7) and lowest available soil phosphorus (40.23 kg ha^{-1}) was found under application of 100% RDF only (T_1). The data given in Table 3 revealed that nutrient management treatments did not show significant effect on the available potassium in soil after harvest of the crop but numerically higher available potash in soil after harvest of crop (206.95 kg ha^{-1}) was obtained with an application of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobactor* (T_7) and lower available soil potassium (174.20 kg ha^{-1}) was found under application of 100% RDF only (T_1).

The data narrated in Table 3 indicated that significantly the higher sulphur content (10.86 mg kg^{-1}) in soil after harvest of crop was noticed under the application of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobactor* (T_7) as compared to T_1 and T_2 treatments but it remained statistically at par with rest of the treatments. The lowest available sulphur status (8.66 mg kg^{-1}) was obtained with the application of 100% RDF alone (T_1). This might be due to addition of FYM increases the availability of native sulphur and FYM is also a source of sulphur which added sulphur to the soil causes increase in available pool of sulphur in soil. Similar results were also reported by Singh *et al.* (2006[b]) [16] and Mohapatra and Dixit (2010) [8].

Table 1: Initial physico-chemical properties of the experimental soil

Sr. No.		Properties	Values of soil depth 0-15 (cm)	Method	Reference
1		**Mechanical Properties**			
	(a)	Sand (%)	84.32	International Pipette method	Piper, 1966
	(b)	Silt (%)	7.34		
	(c)	Clay (%)	8.05		
	(d)	Textural classes	Loamy sand		
2		**Chemical Properties**			
	(a)	Soil $pH_{1:2.5}$	7.62	Potentiometry	Jackson (1973)
	(b)	$EC_{1:2.5}$ (dSm^{-1})	0.11	Conductometry	Jackson (1973)
	(c)	Organic carbon (%)	0.18	Modified Walkley and Black method	Walkley and Black (1934)
	(d)	Available N (kg ha^{-1})	140.31	Alkaline $KMnO_4$ method	Subbiah & Asija (1956)
	(e)	Available P_2O_5 (kg ha^{-1})	42.00	Olsen's method (0.5 M $NaHCO_3$, pH 8.5	Olsen *et al.* (1954)
	(f)	Available K_2O (kg ha^{-1})	204.02	Neutral N NH_4OAc Flame photometry method	Jackson (1973)
	(g)	Available S (mg kg^{-1})	9.80	Turbidimetric method (0.15% $CaCl_2$)	Williams & Steinbergs (1959)

Table 2: Effect of integrated nutrient management on growth, yield attributes, yield and oil content and oil yield on sesamum

Treatments	Plant height (cm)	Number of branches $plant^{-1}$	Number of capsules $plant^{-1}$	Test weight (g)	Seed yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
T_1	61.17	3.06	54.76	2.83	780	1921	47.53	371
T_2	61.53	3.10	55.59	2.94	782	1940	47.55	372
T_3	67.44	3.31	63.27	3.20	863	2201	48.68	420
T_4	67.17	3.27	62.20	3.16	825	2120	48.50	400
T_5	64.84	3.19	60.34	3.10	803	2070	48.40	388
T_6	64.21	3.14	57.63	3.02	794	1997	48.36	384
T_7	75.74	4.02	74.30	3.57	978	2368	49.25	481
T_8	74.95	3.79	70.74	3.45	940	2298	49.22	463
T_9	74.24	3.61	66.60	3.25	933	2256	49.17	458
T_{10}	67.63	3.50	63.52	3.20	892	2225	49.10	438
S.Em. ±	3.57	0.19	4.02	0.02	37	88	0.74	17
C.D. at 5%	NS	0.57	11.94	NS	100	261	NS	50
C.V. %	9.20	9.70	11.07	10.92	6.79	7.12	2.82	6.95

Table 3: Effect of integrated nutrient management on soil chemical properties after harvest of sesamum

Treatments	OC (%)	EC (dS m^{-1})	pH	Av. Sulphur (mg kg^{-1})	Available nutrient (kg ha^{-1})		
					Nitrogen	P_2O_5	K_2O
T_1	0.17	0.123	7.73	8.66	139.87	40.23	174.20
T_2	0.18	0.128	7.70	8.86	140.93	44.25	180.25
T_3	0.19	0.125	7.48	10.74	146.24	43.49	194.05
T_4	0.18	0.120	7.50	10.54	145.46	43.23	192.66
T_5	0.18	0.129	7.58	10.14	142.40	42.22	187.28
T_6	0.17	0.130	7.62	10.07	141.03	40.68	185.85
T_7	0.19	0.130	7.44	10.86	151.78	46.80	206.95
T_8	0.18	0.123	7.47	10.81	147.03	46.36	203.41
T_9	0.19	0.121	7.52	10.45	144.03	46.29	190.55
T_{10}	0.18	0.121	7.53	10.25	143.40	45.27	189.84
S.Em. ±	0.02	0.01	0.17	0.34	2.27	1.67	8.65
C.D. at 5%	NS	NS	NS	1.01	6.73	NS	NS
C.V. %	4.09	3.38	3.95	5.78	2.72	6.58	7.87

References

1. Basu M, Mondhal P, Basak RK, Basu TK, Mahapatra SC. Effect of cobalt, rhizobium and phosphobacterium inoculations on yield and nutrient uptake in summer groundnut (*Archis hypogaea* L.) on Alluvial soils. Journal of Indian Society of Soil Science. 2006; 54:60-64.
2. Deshmukh MR, Jain HC, Duhoon SS, Goswami U. Integrated nutrient management in sesame for Kymore plateau zone of M.P. Journal of Oilseeds Research. 2002; 19(1):73-75.
3. Duboon SS, Jyotishi A, Deshmukh MR, Singh NB. Optimization of sesame (*Sesamum indicum* L.) production through bio/natural inputs. 4th International Crop Science Congress Brishbane Australia, 2004.
4. Duhoon SS, Deskmukh MR, Jain HC, Goswami U. Integrated nutrient management in Sesame for Kymore plateau zone of Madhya Pradesh. Journal of Oilseeds Research. 2002; 19:73-75.
5. Ghosh DC. Growth and productivity of summer sesame (*Sesamum indicum* L.) as influenced by biofertilizer and growth regulator. Indian Journal of Agronomy. 2000; 45(2):389-394.
6. Jaishankar S, Wahab K. Effect of integrated nutrient management on the growth, yield components and yield

of Sesame. Sesame and Safflower Newsletter. 2005; 20:732.
7. Manna MC, Biswas JN. Comparative performance of cow dung slury microbial inoculum and inorganic fertilizers on maize. Journal of the Indian Society of Soil Science. 1996; 44:526-528.
8. Mohapatra AKB, Dixit L. Integrated nutrient management in rainy season groundnut. Indian Journal of Agronomy. 2010; 55(2):123-127.
9. Mousavi A, Sani B, Sharifi M, Hosseini-Nejad Z. Effect of Phosphate Solubilizing Bacteria and Mycorrhizal Fungi on Corn Yield. Journal of Iranian Agriculture. 2005; 2:26-36.
10. Palaniappan SP, Jeybal A, Chelliah S. Evaluation of integrated nutrient management in summer sesame (*Sesamum indicum* L.). Sesame & Safflower Newsletter. 1999; 14:32-35.
11. Panse VG, Sukhatne PV. Statistical Methods for Agricultural Workers (Second Edn.). Indian Council of Agricultural Research, New Delhi, 1985.
12. Pathak K, Barman U, Kalita MK, Hazarika BN. Effect of nitrogen levels on growth and yield of sesamum (*Sesamum indicum*) in Barak Valley Zone of Assam, Advances in Plant Sciences. 2002; 15(1):341-343.
13. Purushottam G. Integrated nutrient management in sesame (*Sesamum indicum* L.) and its residual effect on succeeding chickpea (*Cicer arietinum* L.). M.Sc. Thesis (un published), UAS, Dharwad, Karnataka, 2005.
14. Singh GR, Chaure NK, Sharma RN, Thakur BS. Seed yield, quality and economics of summer sesame (*Sesamum indicum*) as influenced by time of nitrogen application. Indian Agriculturists. 2006a; 50(2):5-7.
15. Singh PK, Prakash OM, Singh BP, Prakash O. Studies on the effect of N fertilization and weed control techniques on weed suppression, yield and nutrient uptake in sesame (*Sesamum indicum* L.). Indian Journal of Weed Science. 2001; 33(3-4):139-142.
16. Singh S, Singh RN, Prasad J, Singh BP. Effect of integrated nutrient management on yield and uptake of nutrients by rice and fertility in rainfed uplands. Journal of the Indian Society of Soil Science. 2006b; 54(3):327–330.
17. Subrahmaniyan K, Arulmozhi N. Response of sesame (*Sesamum indicum*) to plant population and nitrogen under irrigated condition, Indian Journal of Agronomy. 1999; 44(2):413-415.
18. Sujathamma P, Reddy DS, Reddy BS. Direct, residual and cumulative residual effect of nitrogen on yield parameters, yield and nitrogen uptake of sesame in rice groundnut-sesame cropping system. Annual Agriculture Research. 2003; 24(3):587-592.
19. Tiwari RK, Namdeo KN, Jha G. Effect of nitrogen and sulphur on growth, yield and quality of sesame (*Sesamum indicum* L.) varieties. Research on Crops. 1995; 1(2):163-164.
20. Tripathy S, Bastia DK. Irrigation and nutrient management for yield augmentation of summer sesame (*Sesamum indicum* L). Journal of Crop and Weed. 2012; 8(2):53-57.
21. Verma S, Singh HV, Saxena R. Relative performance of sesame (*Sesamum indicum* L.) under organic, inorganic and integrated nutrient management. Indian Journal of Agricultural Sciences. 2012a; 83(3):143–149.
22. Piper CS. Soil and Plant Analysis. Hans Publishers, Bombay, 1966.
23. Jakson ML. Soil Chemical Analysis, Prentice-Hall of India Private Limited, New Delhi, 1973.
24. Walkley A, Black CA. Estimation of organic carbon by chromic acid titration method. Soil Science. 1934; 37:29-38.
25. Subbiah BV, Asija GL. A rapid procedure for determination of available nitrogen in soil. Current science. 1956; 25:259-260.
26. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circulation from USDA. 1954, 939.
27. Williams CH, Steinbergs A. Soil sulphur fraction as chemical indices of available sulphur in some Australian soils. Australian Journal Agriculture Research. 1959; 10:340.