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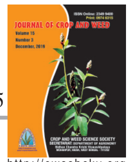

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Nutrient dynamics of China aster (*Callistephus chinensis*) cv. Kamini with organics, inorganic and biofertilizers

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ABSTRACT

An experiment was conducted for two successive years 2016-18 during fall to assess the influence of nutrients applied into aster on plant and soil nutrient dynamics.The experiment was laid out in randomized complete block design (RCBD) with three replications and thirteen treatment combinations comprising of FYM, vermicompost and biofertilizers viz. Phosphate Solublising Bacteria (PSB) and Azospirillum. All the treatment combinations showed significant response on plant nutrient uptake and soil nutrient availability during entire investigation.The treatment combination T_{12}(Azospirillum+PSB+vermicompost+50%RDF) showed highest nitrogen, phosphorus, potassium uptake in flower (97.01kg ha^{-1}, 15.60kg ha^{-1}, 73.02kg ha^{-1}), Potassium use efficiency in plants (80.52kg kg^{-1}),apparent phosphorus recovery (39.31%)and post-harvest available phosphorus of the soil (105.64kg ha ^{1}),whilst phosphorus uptake in soil at harvest (99.91kg ha^{-1})was observed with T_{11} (Azospirillum+PSB+FYM+50%RDF). Maximum nitrogen use efficiency (58.01kgkg^{-1}), phosphorus use efficiency (108.78kg kg^{-1}) and apparent nitrogen recovery (185.04%) was recorded to be the highest with T_{10}(Azospirillum+PSB+50%RD'N' and'P'+100%RD'K').The study showed prodigious potential of organics and biofertilizer that could be used for integrated nutrient management in aster.

Keywords : Biofertilizer, FYM, nutrient, recovery, efficiency, vermicompost

China aster (*Callistephus chinensis* L. Nees.), family Asteraceae, is a significant commercial flower. Plant is robust, free blooming and annual in nature grown as cut flower and loose flower both. The diverse range of forms, colors and prolonged vase life makes aster as most rife cut flower. Wide spread cultivation of aster befell in the cities, metros being for prime components of bouquet, buttonhole, garland *etc*. It also dwells as bed plants, edge making, pot culture and border in landscaping. Proper maintenance of nutrition in the soil with organics are supportive in augmenting growth, quality, eventual yield in ornamental crops (Kumar and Sharma, 2013). Nevertheless, undiscerning and continued use of inorganic fertilizer leads to decline of soil health as of physical and chemical properties, diminution in microbial activities along with vegetative growth and production of flowers.

Organic manures like vermicompost and farm yard manure evinced as advantageous in fixing atmospheric nitrogen, solubilises immovable phosphorus into the soil and enhances auxin levels, thus by, promoting better growth and development of the ornamental plants.These organic manures intensify the accessibility of soil nutrients, expands the soil properties, thus, known for an excellent organic manure for sustaining good soil health (Chahal *et al*., 2020). Biofertilizers like *Azospirillum* and PSB assist in improving soil fertility, stimulating plant growth, development and saves application of nitrogenous fertilizers upto 20-25 per cent. Thus, management of soil fertility in an integrated manner through sensible unification of organic manure, biofertilizer and inorganic fertilizer appears as a feasible opportunity for sustainable agriculture on commercial and lucrative scale (Singh *et al*., 2015). Nutrient use efficiency (NUE) helps in improving the aster production systems. Increasing the nitrogen use efficiency (NUE) becomes important as it bridge the gap between consumption and demand for nitrogenous fertilizer (Xu *et al*., 2012). Actually, the apparent nutrient recovery (ANR) index assesses to engross nitrogen in the soil of crop grown (Greenwood and Hunt, 1986). Apparent nutrient recovery (ANR) also exhibited differences about the contribution of innate soil nutrients accrued in unfertilized and fertilized plot. Thus, NUE and ANR helps in determining the efficiency of nitrogenous fertilizer management practices (Zemenchik and Albrecht, 2002). The uptake and use efficacy of nutrients, nutrients recovery, nutrient uptake by soil and aster crop may be improved by advocating judicious and combined use of organics, inorganic and biofertilizer. Hence, the present experimentation was conducted for the appraisal of combined approach with organics, nitrogenous fertilizer, biofertilizer for nutrient availability and uptake by aster.

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MATERIALS AND METHODS

The present research was conducted at horticultural experimental sites at North-Eastern Hill University, Tura, Meghalaya in 2016-17 and 2017-18. The temperature and rainfall statistics of experimental seasons were presented in Fig.1. The soil of the experimental plots had organic carbon (0.98-2.65%), $KMnO_4$-N (263.07-288.16 kg ha^{-1}), P (13.38 kg ha^{-1}), K (216.3 kg ha^{-1}) and pH of 4.05-5.51. Thirteen treatments *viz*., absolute control (T_0),100% RDF (T_1), *Azospirillum* + 75% RD'N'+100%RD'P' and'K' (T_2), PSB +75% RD'P'+100%RD'N' and 'K' (T_3), FYM + 50% RDF(T_4), Vermicompost + 50%RDF (T_5), *Azospirillum* + FYM + 50% RDF (T_6), *Azospirillum* + Vermicompost +50% RDF (T_7), PSB + FYM + 50% RD F(T_8), PSB + Vermicompost + 50% RDF(T_9), *Azospirillum* + PSB + 50% RD'N' and 'P' + 100% RD'K'(T_{10}), *Azospirillum* + PSB + FYM + 50% RDF (T_{11}) and *Azospirillum* + PSB + Vermicompost + 50% RDF (T_{12}) were considered for the assessment of appropriate combinations. Randomized completely block design with three replications were apprised for conducting the research. Almost equal size about 15cm in length cultivar Kamini seedlings of China aster were planted at 30 x 30 cm in the field. Nutrient composition of FYM (0.54% N, 0.18% P and 0.51% K), vermicompost (1.45% N, 0.87% P and 0.65%K) was analysed before soil incorporation for maintaining correct composition. Well decomposed cow dungs at 25t ha^{-1} was thoroughly incorporated in respective experimental plots during the final land preparation. Vermicompost at 2.5t $ha^{-1}$was applied at 20 days prior to transplanting and biofertilizers like PSB and *Azospirillum* was applied at 5 kg ha^{-1} during transplanting as per treatment. Recommended dose of fertilizer (N, 180 kg ha^{-1}, P, 120 kg ha^{-1} and K, 60 kg ha^{-1}) was incorporated during final tillage but before transplanting as per treatments schedule except control plot. The plant samples for NPK analysis were collected at 90 days after transplanting. Sample of soil upto15 cm depth in the beginning of crop grown as well as at harvesting of aster flowers were taken and analysed for existing nitrogen (Subbiah and Asija, 1956),existing phosphorus (Motiramani and Wankhede, 1964) and existing potassium (Jackson, 1967).

The uptake of nutrients was estimated using the formula of Piper (1996) and expressed as kg ha^{-1}.

Nutrient uptake = Contents of nutrient (percent) x Productions of dry matter (kg ha^{-1})/100

Apparent nutrient recovery (ANR) was computed using the formula as stated below (Jalpa *et al.*, 2020) and was expressed in percentage.

ANR (%)=(Uptake of nutrients in treated plot-Uptake of nutrients in control plot)/Nutrient incorporated (kg ha^{-1}) x 100

Uptake efficiencies of nitrogen, phosphorus and potassium was computed using formula (Sandana, 2016) and was expressed in kg kg^{-1}.

Uptake efficiencies of nutrients = Uptake of nutrients in plant/Supply of nutrients

Use efficiencies of nutrients specifies production of aster flower were computed as per the method stated by Gitari *et al.* (2018) and was expressed in kg kg^{-1}

Use efficiencies of nutrients = Aster flower yield ÷ Total nutrient supply

The collected data from all traits were pooled and analysed statistically according to the techniques (ANOVA) for completely randomized block design as suggested by Gomez and Gomez (2010).

RESULTS AND DISCUSSIONS

Significant response on nutrient uptake by leaves, stem and flower of aster under various treatment combinations influenced by organic, inorganic and biofertilizer are presented in Fig. 2, 3, 4. Increased nitrogen uptake in aster leaves was noticed in the treatments *Azospirillum* + PSB + Vermicompost + 50% RDF (83.58 kg ha^{-1}), *Azospirillum* + PSB + 50% RD 'N' and 'P'+ 100% RD 'K'(79.02 kg ha^{-1}). However, maximum phosphorus uptake was found in *Azospirillum* + PSB + Vermicompost + 50% RDF (9.95 kg ha^{-1}) followed by PSB+75% RD'P'+100%RD'N' and 'K' (7.54 kg ha^{-1}). Whereas, greater uptake of potassium from *Azospirillum* + PSB + Vermicompost + 50% RDF (37.59 kg ha^{-1}) followed by *Azospirillum* + PSB + 50% RD 'N' and 'P' + 100% RD 'K' (35.75 kg ha^{-1}) was observed. Adequate nitrogen uptake with appropriate nutrient management for encouraging activity in rice plant was opined by Thakur *et al.* (2020). More nitrogen uptake in stem with *Azospirillum* + PSB + Vermicompost + 50% RDF (162.30 kg ha^{-1}), *Azospirillum* + 75% RD 'N' + 100% RD 'P' and 'K' (154.92 kg ha^{-1}) were noticed. Whilst, enhanced phosphorus uptake in *Azospirillum* + PSB + Vermicompost + 50% RDF (6.18 kg ha^{-1}) was observed. But, maximum potassium uptake in *Azospirillum* + PSB + 50% RD 'N' and 'P' + 100% RD 'K' (5.64 kg ha^{-1}) did not differ significantly with *Azospirillum* + PSB + Vermicompost + 50% RDF (5.28 kg ha^{-1}). Maximum nitrogen uptake in aster flowers were noticed from the treatment *Azospirillum* + PSB + Vermicompost + 50% RDF (97.01 kg ha^{-1}), *Azospirillum* + PSB + FYM + 50% RDF (80.99 kg ha^{-1}) and FYM + 50% RDF (72.56 kg ha^{-1}). More nitrogen uptake with collective use of organics, inorganic fertilizer and biofertilizer in aster flower probably might be due to nutrients accessibility, advantageous micro-organisms, vegetative growth promoting substances (Vimala *et al.*, 2006). However, maximum phosphorus uptake in *Azospirillum* + PSB + Vermicompost + 50% RDF(15.60 kg ha^{-1}), FYM +50% RDF (11.87 kg ha^{-1}) and

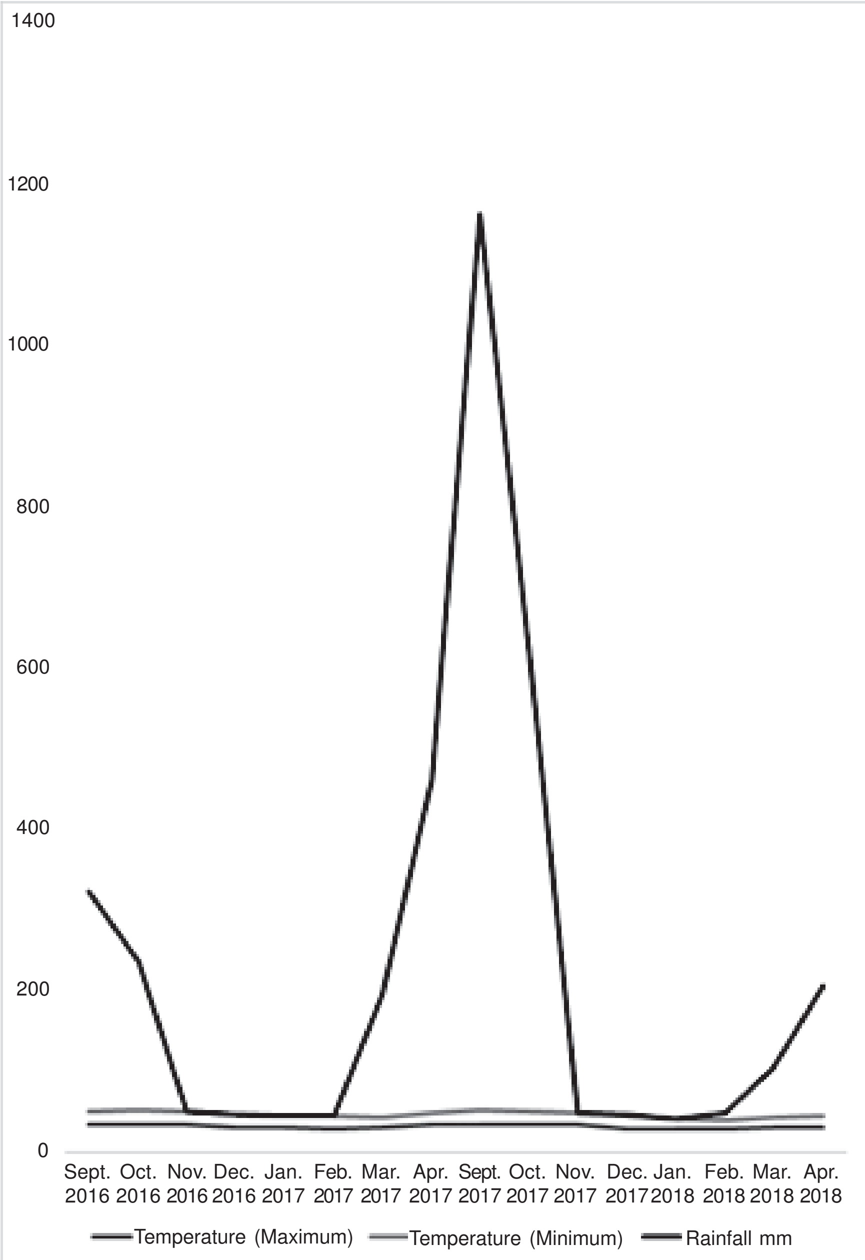

Fig.1: Temperature and rainfall statistics of experimental season

Azospirillum + PSB + FYM + 50% RDF (7.96 kg ha^{-1}) were found. Organic manures in association with biofertilizer significantly increased the phosphorus uptake in aster. Whilst, increased potassium uptake with *Azospirillum* + PSB + Vermicompost + 50% RDF (73.02 kg ha^{-1}) in aster was noticed. Significant nutrient uptake by aster leaves, stem and flower had been observed from combined application of organic and bio-fertilizer supplemented with 50% RDF as compared to 75% RDF and 100% RDF. Highest uptake of nitrogen, phosphorus and potassium in flower than leaves and stem were noted. Higher nutrient uptake might be due to presence of organics and biofertilizer in the soil which may hold the nutrients, increased the accumulation of soil nitrogen and retained losses (Prativa and Bhattarai, 2011).

Contrary, 75% RDF and 100% RDF treated plots, additional nutrients were available in the soil but uptake skimpy might be due to leaching, volatilization and less competence of the crop for engraving the nutrients. Moreover, plots without organic manure and biofertilizer, the uptake of phosphorus was diminutive due to less solubility. Decrease in potassium uptake under 100% RDF as compared to integrated nutrient management practices was also observed by Bahadur *et al*. (2004).

Response on nutrient uptake efficiency, efficiency of nutrient used and nutrient recovery in aster under

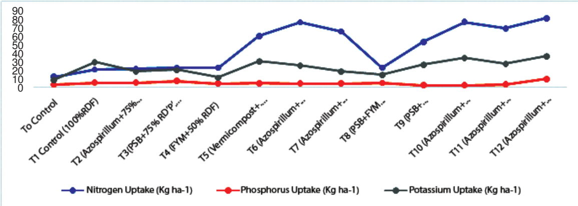

Fig. 2: NPK uptake by aster leaves

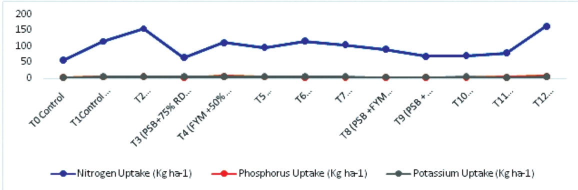

Fig. 3: NPK uptake by aster stem

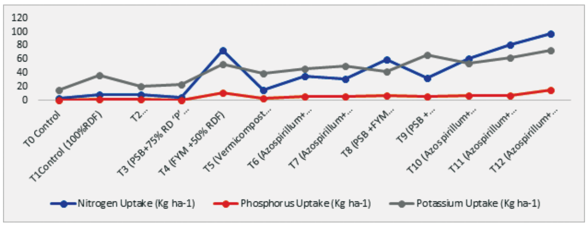

Fig. 4: NPK uptake by aster flowers

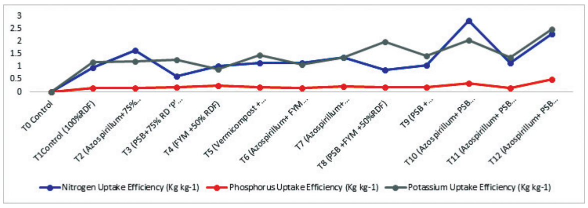

Fig. 5: NPK uptake efficiency by aster plant

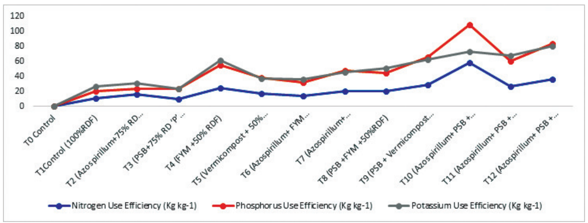

Fig. 6: NPK use efficiency by aster plant

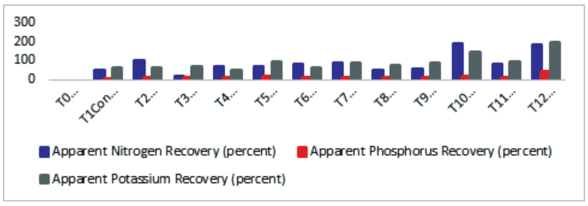

Fig. 7: Apparent nutrient recovery by aster plant

various treatment combinations influenced by organic, inorganic and biofertilizer were presented (Fig. 5, 6, 7). Increased nitrogen uptake efficiency by aster was noticed with treatment combinations of *Azospirillum* + PSB + 50% RD 'N' and 'P'+100% RD 'K'(2.81 kg kg^{-1}), *Azospirillum* + PSB + Vermicompost+50%RDF (2.28 kg kg^{-1}) and *Azospirillum* + Vermicompost + 50% RDF (1.35 kg kg^{-1}). However, enhanced phosphorus uptake efficiency in *Azospirillum* + PSB + Vermicompost + 50% RDF (0.49 kg kg^{-1}) followed by *Azospirillum* + PSB + 50% RD 'N' and 'P'+ 100% RD 'K' (0.33 kg kg^{-1}) was observed. Whilst, maximum potassium uptake efficiency in *Azospirillum* + PSB + Vermicompost + 50% RDF (2.49 kg kg^{-1}), *Azospirillum* + PSB + 50% RD 'N' and 'P' +100% RD 'K' (2.04 kg kg^{-1}) was observed. The augmented nutrient uptake efficiency with combined use of organic, inorganic and biofertilizer could be attributed because of alteration in rainfall occurrence. The decisive role has been played by the water for accessing the competence of the plants in absorbing nutrient of the soil (Irena and Mauromicale, 2012; Su *et al*., 2014). Nevertheless, November-December-January 2016 and 2017 had perilous weather circumstances with teensy or no rainfall, maintenance of adequate moisture level at the aster field played imperative role in solubilizing nitrogen, phosphorus and potassium, henceforth making it available for aster. Increased nitrogen and phosphorus use efficiency was noticed in *Azospirillum* + PSB + 50% RD 'N' and 'P' + 100% RD 'K' (58.01 kg kg^{-1} and 108.78 kg kg^{-1}), *Azospirillum* + PSB + Vermicompost + 50% RDF (36.23 kg kg^{-1} and 83.62 kg kg^{-1}) and PSB + Vermicompost + 50% RDF (28.18 kg kg^{-1} and 65.03 kg kg^{-1}). However, maximum potassium use efficiency with *Azospirillum* + PSB + Vermicompost+50% RDF (80.52 kg kg^{-1}), *Azospirillum* + PSB + 50% RD 'N' and 'P'+100% RD 'K'(72.52 kg kg^{-1}), *Azospirillum* + PSB + FYM + 50% RDF (67.15 kg kg^{-1}) was observed. Addition of organic manure encourages the augmented use efficiency of nutrients (Bacca *et al*., 2020). The collective usage of organic manures, inorganic fertilizers and biofertilizers maintains a continuous nutrient supply, diminish losses and augment for efficient consumption of the applied nitrogenous source (Golla, 2020).Increased percentage of apparent nitrogen recovery in *Azospirillum* + PSB + 50% RD'N' and 'P' + 100% RD 'K' (185.04%), *Azospirillum* + PSB + Vermicompost + 50% RDF (180.85%) was noted. However, more percentage of apparent phosphorus and potassium recovery in *Azospirillum* + PSB + Vermicompost + 50% RDF (39.31% and 195.95%) were observed. A zero value of apparent nutrient recovery in absolute control plot specifies that accumulation of

Table 1: NPK uptake of soil at harvest stage and post harvest available nutrients of the soil as influenced by organic, inorganic and biofertilizer

Treatments	NPK uptake at harvest stage (Kg ha^{-1})			Soil nutrients availability after harvest (Kg ha^{-1})		
	N	P	K	N	P	K
T_0	210.52	43.36	358.96	256.46	54.52	480.45
T_1	308.92	71.68	627.82	400.66	86.46	884.26
T_2	289.70	73.02	873.68	438.89	90.29	985.62
T_3	313.75	89.21	582.18	496.51	97.61	896.45
T_4	241.63	98.56	672.27	486.88	99.75	943.44
T_5	381.13	89.61	660.26	443.65	98.56	851.14
T_6	371.84	89.62	687.20	472.88	101.60	728.12
T_7	448.42	92.73	582.41	468.54	95.73	660.80
T_8	361.85	79.24	649.64	544.52	104.82	873.63
T_9	347.17	92.63	716.60	405.26	94.65	761.87
T_{10}	395.52	81.98	750.65	424.37	80.41	851.86
T_{11}	390.77	99.91	660.89	467.63	98.56	929.68
T_{12}	501.39	103.40	953.54	573.41	105.64	996.84
LSD (0.05)	**46.22**	**9.00**	**85.83**	**67.09**	**10.56**	**59.77**
CV (percent)	**7.61**	**6.12**	**7.35**	**8.57**	**6.56**	**4.14**

nutrients in treated and untreated plot did not differ with each other (Mengel and Kirkby, 2006). Kadiyala *et al*. (2014) noticed apparent nitrogen recovery decreased with enhanced rate of nitrogen application.

Significant results on nutrient uptake by soil at harvest and postharvest stages from aster field under various treatment combinations influenced by organic, inorganic and biofertilizer are presented in Table 1. Higher nitrogen and phosphorus uptake by the soil at harvest was found with *Azospirillum* + PSB + Vermicompost + 50% RDF (501.39 kg ha^{-1} and 103.40 kg ha^{-1}), *Azospirillum* + Vermicompost + 50% RDF (448.42 kg ha^{-1}and 92.73 kg ha^{-1}) and *Azospirillum* + PSB + 50% RD 'N' and 'P' + 100% RD 'K'(395.52 kg ha^{-1} and 81.98 kg ha^{-1}). However, more uptake of potassium in *Azospirillum* + PSB + Vermicompost + 50% RDF (953.54 kg ha^{-1}), *Azospirillum* + PSB + 50% RD 'N' and 'P'+100% RD 'K' (750.65kg ha^{-1}), *Azospirillum* + PSB + FYM + 50% RDF (660.89 kg ha^{-1}) were noted. Increased nutrient contents of the soil probably might be due to the usage of organic, inorganic and biofertilizer due to traversable source of soil nutrients as of mineralization. Whereas, decreased availability of soil nitrogen, phosphorus and potassium at harvest stage than postharvest stage could be due to more vegetative growth, acidification of organic manures by increasing nutrients availability and uptake of nitrogen, phosphorus and potassium into aster plants. Addition of organic constituents of different origins into the soil is utmost practices to improvise physical properties of soils (Celik *et al.,* 2004). At postharvest stages, higher available nitrogen in the soil was found in *Azospirillum* + PSB + Vermicompost + 50% RDF (573.41 kg ha^{-1}), PSB + 75% RD'P' + 100% RD 'N' and 'K'(496.51 kg ha^{-1}) and *Azospirillum* + PSB + FYM + 50% RDF (467.63 kg ha^{-1}). However, maximum availability of phosphorous in *Azospirillum* + PSB + Vermicompost + 50% RDF (105.64 kg ha^{-1}), PSB+ Vermicompost + 50% RDF (94.65 kg ha^{-1}) was noticed. More available potassium in *Azospirillum* + PSB + Vermicompost + 50% RDF (996.84 kg ha^{-1}), *Azospirillum* + PSB + FYM + 50% RDF (929.68 kg ha^{-1}), *Azospirillum*+PSB +50%RD 'N' and 'P' + 100% RD 'K' (851.86 kg ha^{-1}) was observed. The aforesaid findings of accumulated nutrients in residual forms after harvesting gladiolus was supported by Chandana and Dorajeerao (2014). Decreased available nutrient by the soil at postharvest stage as residual nutrient in the control could be due to depletion of intrinsic pool of accessible nutrients of plants after mineralization (Shirsat *et al.,* 2015).

The conducted experiment divulges that use of well decomposed manure, vermi-compost, biofertilizer in addition of recommended doses of inorganic fertilizer exhibited encouraging results on the nutrient dynamics thereby promoting growth, development and quality characters of China aster plants. Entire investigations concluded that *Azospirillum* + PSB + Vermicompost + 50% RDF followed by *Azospirillum* + PSB + FYM + 50% RDF and *Azospirillum* +PSB + 50% RD 'N' and 'P' + 100% RD'K' became more germane due to the better nutrient uptake, nutrient uptake efficiency, use efficiency of nutrients, recovery of nutrients by aster plant as well as presence of adequate nutrients at harvest stage and residual nutrients at postharvest stage in the soil.

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