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Effect of inorganic modules on yield, nutrition composition and nutrient use effeciency in pea (*Pisum sativum*)

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Abstract
A field experiment was conducted during Rabi 2002 to 2005 to find out the effect of macro and micro nutrients on vegetable pea. Result indicated that Azad P-1 produced significantly higher yield and content of N, P and S in grain and straw (11.3 q/ha, 0.59-0.45, 2.7-3.9, and 0.42-0.37%) respectively compared to Azad P-3 and Arkel during trials. Significantly high biochemical constituents of pea seeds viz, vitamin C, reducing sugar, protein and carbohydrate 28.6mg/100gm, 3.3, 55.4 and 24.2% respectively found in Azad P-3 compared to Arkel and Azad P-1.Under inorganic modules recommended dose of NPK plus S with Mo & Fe @ 50 ppm foliar spray caused marked increased all yield and yield attributes, interaction impact on grain & fresh pod yield and biochemical constituents of Vitamin C, reducing sugar, protein and carbohydrate (11.49 q/ha76.8%and 91.4,q/ha, 89.2%,30.8 mg/100gm,3.4%,25.7%,and57.3%) respectively followed by application of recommended dose NPK plus S @ 20 kg/ha and Fe @ 50ppm foliar spray. Synergetic relation between sulphur, molybdenum and iron markedly improved nutrient use efficiency and percentage return to fertilizers under foliar spray of Mo and Fe compared to other treatments.

Keywords: yield, nutrition composition and nutrient use efficiency

Introduction
Pea is commonly grown throughout India. It is consumed both as green pod and dry seed which indeed rich in nutritive values. In eastern U.P. particularly in Varanasi region pea is mostly grown as vegetable crop. The farmers of these region are using quiet a few varieties of pea. Among these Azad P-1, Azad P-3 and Arkel are the most commonly and widely accepted varieties. The farmers to reap high yield and better economic return generally follow a number of agronomic practices. The farmers of these regions are not using balance dose of NPK and micronutrient due to neither there is sufficient scientific awareness regarding the effects and use of balance dose of NPKS and micronutrients (Mo &Fe). Therefore the present experiment was planned to get detailed information about the effectiveness of macro and micronutrient combination on enhance the productivity and quality of pea. Its possible only when balanced and adequate supply of major and micronutrient for higher production, nutrient use efficiency and improve quality of pea crop (Kandeel 2002, Chidtdeshwahari and poongatha 2004, Babu and Rao 2004) [4, 2, 1]. Because macro and micro nutrients combination influences the nitrogenase and hydrogenase enzyme activity through in the presence Azofer' and Azofermo enzyme in Fe and Mo protein constituents. Simultaneously higher nitrogenase activity enhanced N-fixation which in turn had positive effect on photosynthesis resulted on increase yield, (Srivastava and Ahlawat, 1995) [11]. This technology can help realize the long cherished goal of making country for sufficient vegetable pea production. Thus the present investigation was under taken which a view to find out the effect of nitrogen, phosphorus, potash with sulphur, iron, molybdenum on yield quality and nutrient use efficiency.

Materials and Methods
A field experiment was conducted to evaluate the impact of sulphate, molybdate and iron along with recommended dose of NPK. Application of its combination to enhance the yield and biochemical constituents of vegetable pea seeds at Indian Institute of Vegetable Research farm (82.52^0 longitudes and 25.10^0 N latitude), Varanasi (U.P).The basic properties of the soil during this experiment was as fallows pH 7.6, EC 0.41 dSm^{-1}, available N $_{270}$ kg ha^{-1}, P_2O_5 $_{18}$ kg ha^{-1} and K_2O $_{180}$ kg ha^{-1} sulphur 10 kg ha^{-1}, organic carbon 0.38% and (Ca^{+2} + Mg^{+2}) 6.42 meq/100 g soil and Just before sowing. The treatment combination viz., T_0 (Nitrogen, Phosphorus, Potash $_0$ kg/ha), T_1 (Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$ kg/ha), T_2(Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$+ Sulphur $_{20}$ kg/ha), T_3 (Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$ + Sulphur $_{40}$ kg/ha), T_4 (Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$ +Iron @ 10kg/ha T_5 (Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$ + Iron @ 100 ppm spray (15, 30,and 45 days after sowing), T_6 (Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$ + Iron @ 10kg/ha+ Sulphur $_{20}$kg/ha) T_7 (Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$ kg/ha + Iron @ 50 ppm spray) T_8 (Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$ + Sulphur $_{20}$ kg/ha + Iron @ 100 ppm spray) T_9 (Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$ + Sulphur $_{20}$ kg/ha + Iron @ 50 ppm spray) T_{10} (Nitrogen $_{30}$, Phosphorus $_{60}$, K Potash $_{80}$ kg/ha + Iron @ 10kg/ha) T_{11} (Nitrogen $_{30}$, Phosphorus $_{60}$, Potash $_{80}$ + Sulphur $_{20}$ kg/ha +

Molybdenum and Iron @ 50 ppm spray at 15, 30 and 45 days after sowing. Nitrogen, Phosphorus, Potash and Sulphur applied as basal dose through, urea, diammonium phosphate, murate of potash and sulphur respectively. Whenever micronutrient iron and molybdenum through ferrous sulphate and sodium hepata molybdate @50 and 100ppm spraying in crop of three times at 15 days interval were evaluated in splite plot design with three replicatin. The size of each plot was $5m^2$ recommended agronomic practices and plant protection measures were fallowed as per recommendation. The crop was irrigated at active growth stage and pod initiation stage. Observation of yield was taken at physiological maturity. The crop was harvested grain and straw yields per treatment were recorded separately. Grain and straw samples were taken dried at 48 hours 75 ºC temperature then after grind sample to pass through a 2mm sieve. Pea grain and straw powder were used for biochemical analysis. The Nitrogen in seed estimated by (modified Kjedahls, Jackson 1967) [3] and phosphorus and sulphur in seed and straw estimated by Jackson 1967 [3] and percentage of protein was calculated multiplying the nitrogen percentage by a factor 6.25. The uptake of nutrient kg/ha (Nitrogen, Phosphorus and Sulphur) was calculated from concentration of nutrient in grain multiplied by yield (q/ha).The ascorbic acid, reducing sugar and carbohydrate determined by volumetric, dinitro salicylic acid and phenol sulphuric acid method respectively according to Sadasivam and Manickam 1996 [9]. The derivations of different productivity and use efficiency components were total uptake of nutrients, agronomic use efficiency, chemical use efficiency, and percentage return to fertilizer in term of yield was calculated by following the method of Santos *et.al*. 2003 and Baligar *et al.* 2001.

Results and Discussion

Grain Yield

The application of sulphur @ 20 kg/ha and molybdenum and iron @ 50 ppm on foliar spray along with recommended dose of NPK yielded maximum grain and fresh pod yield attribute (11.49 and 95q/ha, which was 76.3and 96.6%) as compared to control treatment of pea yield figure1. Greater availability of nutrients lead to increased assimilation of photosynthates per unit leaf area resulting in more plant vigor, which ultimately gave higher yield and interaction impact. The findings were in good according with the reports of Kumawat and Khongarot 2002, Prasad and Prasad 2003, Chidtdeshwahari and poongatha 2004) [5, 8, 2].The application of Fe and Mo significantly influenced pea yield. Because it influences the nitrogenase and hydrogenase enzyme activity through in the presence Azofer' and Azofermo enzyme in Fe and Mo protein constituents. Simeltoneously higher nitrogenase activity enhanced N-fixation which in turn had positive effect on photosynthesis resulted on increase in yield, (Srivastava and Ahlawat, 1995) [11]. Combined application of sulphur and molybdenum gave maximum yield because it plays a role in chlorophyll synthesis, as active center of some enzyme and affected various metabolic processes which ultimately helped in growth and development of plants (Singh *et al.* 2002) [10].

Nutrition Composition in pea grain

The application of sulphur @ 20 kg/ha plus molybdenum and iron @ 50 ppm foliar spray along with recommended dose of NPK found higher vitamin C, protein, carbohydrate and reducing sugar (30.8 mg/g, 25.7%, 57.7 and 3.4%) respectively fallowed by application of sulphur @ 20 kg/ha+ iron @ 50 ppm foliar spray along with recommended dose of nitrogen, phosphorus, potash (30.0 mg/gm 25.3%, 55.0 % and 3.3 %) also performs (table-1). Because legumes responded well to the application of sulphur, molybdenum and iron which is essential for all plant as it is involved in various metabolic and enzymatic process. The sulphur containing amino acids (methionine, cysteine) play an important role in protein synthesis by this way more utilization of nitrogen, phorous through the application of sulphur, molybdenum and iron similar result was found by Tripathi *et al*. (1997) [13]. The widely accepted thought that sulphur, molybdenum and irone have also synergistic relationship with N and protein metabolism could be the cause of increase in protein content in pea grain supported by Singh *et.al*. (2002) [10]. The sulphur, molybdenum and iron improved the chlorophyll content and induced more assimilation of photosynthates according to Kandeel *et.al.* 2002 [4] while potassium enhances translocation of photosynthates and sugar metabolism under this treatment as reported by Babu and Rao (2004) [1].

Nutrients content and uptake

Application of S @ 20 kg with Mo and Fe @ 50 ppm foliar spray along with recommended dose of NPK (table-1) influenced significantly higher value of nitrogen and phosphorus in grain (4.1and 0.64%) followed by S@ 40 kg along with recommended dose of NPK (4.0and 0.62%) and at pare S @ 20 kg with Fe @ 50 ppm foliar spray along with recommended NPK (table-1). While significantly higher sulphur content in grain and straw was found when the application of S @ 40 kg/ha along with recommended dose of NPK (0.46%) content and uptake of sulphur increased significantly in linear order with increasing in its levels corroborating with the findings of Tripathi *et al.* (1997) [13]. More availability of nitrogen, phosphorus, Mo and Fe with application of sulphur promoting the nodulation through the excite nitrogenase enzyme activity thus improve more N-fixation its due to increase N content in grain and straw due to synergistic impact between Mo, S and N according to Yadav *et.al.* (2002) [16]. Phosphorus status increased of pea grain by secretion root exudates by reducing Soil P^H leads to phosphorus release and desorption of phosphorus by replacing effect of molybdate from soil colloidal compiled through anion exchange phenomena have increased the availability of phosphorus, due to more uptake and content in grain and straw supporting the finding by Menora and Pushpendra (2004). Whenever soil application of iron decreased the P concentration significantly lower compared to control, because of its antagonistic effect on phosphorus reported by Yadav *et al.* (2002) [16].

Nutrient use efficiency verses grain yield

Maximum agronomic, chemical and economical nutrient use efficiency of nitrogen, phosphorus and sulphur was found when the application of S @ 20 kg/ha with Mo and Fe @ 50 ppm foliar spray along with recommended dose of NPK (table-2). Due to more uptake of NPS through synergetic

relationship between each other similarly results supported by Welch (1995) [15]. Therefore more use efficiency of its nutrient by reduce the losses of nutrients. This treatment proved to be the most economically profitable for garden pea production supporting the finding by (Kandeel 2002) [4].

Table 1: Effect inorganic module on quality and nutritional status of Grain and straw of three-pea cultivar.

Treatment	Phosphorus (%)		Nitrogen (%)		Sulphur (%)		Uptake of P by Grain (kg/ha)	Uptake of N by Grain (kg/ha)	Uptake of S by Grain (kg/ha	Grain yield (q/ha)	Vit.C (mg/100 gm)	Reducing sugar in grain (%)	Carbohydrate grain (%)	Protein in grain (%)
	Grain	Straw	Grain	Straw	Grain	Straw								
To	0.32	0.47	2.2	3.5	0.26	.23	3.1	22.7	1.6	6.52	23.6	2.2	47.5	21.9
T_1	0.36	0.56	2.5	3.6	0.27	.26	4.9	35.0	2.5	9.87	27.1	2.7	47.8	22.4
T_2	0.42	0.58	2.7	3.9	0.47	.41	5.9	40.6	3.9	10.74	28.7	3	54.3	22.4
T_3	0.43	0.62	2.7	4.0	0.51	.46	6.0	42.5	4.4	10.81	29.3	3	54.3	24.9
T_4	0.41	0.51	2.4	3.6	0.28	.26	4.8	36.0	2.4	9.75.	26.7	2.9	48.6	22.4
T_5	0.42	0.55	2.6	3.6	0.31	.28	5.1	32.9	2.6	9.43	27.0	3	49.3	22.4
T_6	0.42	0.57	2.6	3.8	0.44	.38	5.5	36.6	3.5	9.86	27.3	3.1	52.1	23.8
T_7	0.46	0.56	2.7	3.8	0.42	.29	5.9	37.7	2.8	9.99	25.4	3.2	48.7	23.7
T_8	0.41	0.60	2.6	4.0	046	.42	6.4	41.3	4.1	10.66	29.9	3.2	53.4	24.9
T_9	0.46	0.61	2.8	4.1	0.48	.42	6.5	43.7	4.4	10.97	30.0	3.3	55.0	25.3
T_{10}	0.56	0.60	2.8	4.0	0.43	.37	6.2	41.7	3.6	10.62	28.3	3	54.4	25.0
T_{11}	0.59	0.64	2.8	4.1	0.48	.44	6.7	46.5	4.6	11.49	30.8	3.4	57.3	25.7
LSD 0.05	0.06	0.05	0.07	0.1	0.04	0.02	0.7	3.4	0.3	0.92	1.3	0.3	4.7	0.5

Table 2: Effect of inorganic module on fertilizers use efficiency in Vegetable pea.

Treatment	FUE on chemically (%)			FUE on Argonomically (Kg/Kg)			FUE on economically (%)		Percentage return to fertilizers		Fertilizers + application cost	Interaction impact on yield		Pod yield (q/ha)
	Nitrogen	Phosphorus	Sulphur	Nitrogen	Phosphorus	Sulphur	Grain	Pods	Grain	Pods		Grain	Pods	
To	-	-	-	-	-	-	290	302		-	-	-	-	48.3.3
T_1	116.66	8.16	-	0.11	0.056	-	358	349	5.54	4.59	2568	51.08	42.2	68.7
T_2	135.33	9.8	19.5	0.14	0.07	0.21	360	399	4.6	5.8	3768	64.6	76.6	85.3
T_3	141.66	10.0	11.0	0.14	0.07	0.11	307	364	2.37	3.73	6368	66.2	89.0	91.3
T_4	120.00	8.0	-	0.11	0.056	-	335	388	3.8	5.73	3368	49.2	67.1	80.7
T_5	109.99	8.5	-	0.096	0.048	-	323	383	3.3	5.48	3400	44.6	65.2	79.8
T_6	122.00	9.17	17.5	0.11	0.056	0.017	317	383	2.8	4.19	4368	52.3	67.1	80.7
T_7	125.66	9.8	-	0.11	0.056	-	351	417	4.7	7.4	3040	52.3	75.8	84.9
T_8	137.66	10.66	20.5	0.14	0.07	0.21	342	397	3.78	5.46	4268	64.6	81.6	87.7
T_9	145.66	10.8	22.00	0.15	0.073	0.22	360	411	4.35	6.25	4168	73.3	89.4	91.5
T_{10}	139.00	10.33	18.00	0.14	0.068	0.21	335	413	3.4	5.46	4668	63.1	89.2	91.4
T_{11}	155.00	11.17	23.00	0.15	0.083	0.25	405	470	5.6	7.60	2968	76.8	96.68	95

Table 3: Effect of inorganic module on quality and nutritional status of grain and straw of three-pea cultivar.

Genotype	Phosphorus (%)		Nitrogen (%)		Sulphur (%)		Uptake of P by Grain (kg/ha)	Uptake of N by Grain (kg/ha)	Uptake of S by Grain (kg/ha	Grain yield (q/ha)	Vit.C (mg/100gm)	Reducing sugar grain (%)	Carbohydrate (%) grain	Protein in grain (%)
	Straw	Grain	Straw	Grain	Straw	Grain								
Arkel	0.44	0.57	2.6	3.8	0.40	0.35	4.9	32.8	2.8	8.5	27.5	3.3	52.3	23.9
AZAD P-1	0.45	0.59	2.7	3.9	0.42	0.37	6.9	45.5	4.2	11.3	27.4	2.9	51.5	23.6
AZAD P-3	0.43	0.55	2.6	3.8	0.39	0.34	4.9	35.9	3.1	9.42	28.6	3.3	55.4	24.2
LSD 0.05	0.03	0.07	0.06	0.7	0.006	0.007	0.8	1.9	0.1	0.58	0.4	0.06	1.6	0.3

Interaction impact on yield and percentage return to fertilizers

The maximum interaction impact on yield (grain and pods) and percentage return to fertilizers in vegetable pea was found 76.8 to 96.7and 5.6 to7.6 under the application of recommended dose of NPK along with S @ 20 kg, Mo and Fe @ 50 ppm foliar spray followed by application of recommended dose of NPK plus S @ 20 kg/ha, and Fe @ 50 ppm foliar spray of three times at fifteen days interval (73.3 to 89.4 and 4.7 to 7.4). Due to synergetic relation between molybdenum and sulphur which plays a role an inactive centre of some enzymes and affected various metabolic processes which ultimately helped more utilization of fertilizers, its due to obtained more percentage return to fertilizers from cited Singh *et. al*. (2002) [10].

Genotypic Performance

Significantly high vitamin C, reducing sugar protein and carbohydrate content were found in Azad P-3 (28.6mg/100gm, 3.3, 55.4 and 24.2%) respectively as compared to Arkel and Azad P-1 (table-3). There were no significant differences of nutrient content in grain among these cultivars (Fig 1, 2).

Phosphorus content was found to be maximum in grain (AzadP-1) where as yield and yield attributes was also significantly high in Azad P-1 compared to Arkel and AzadP-3.

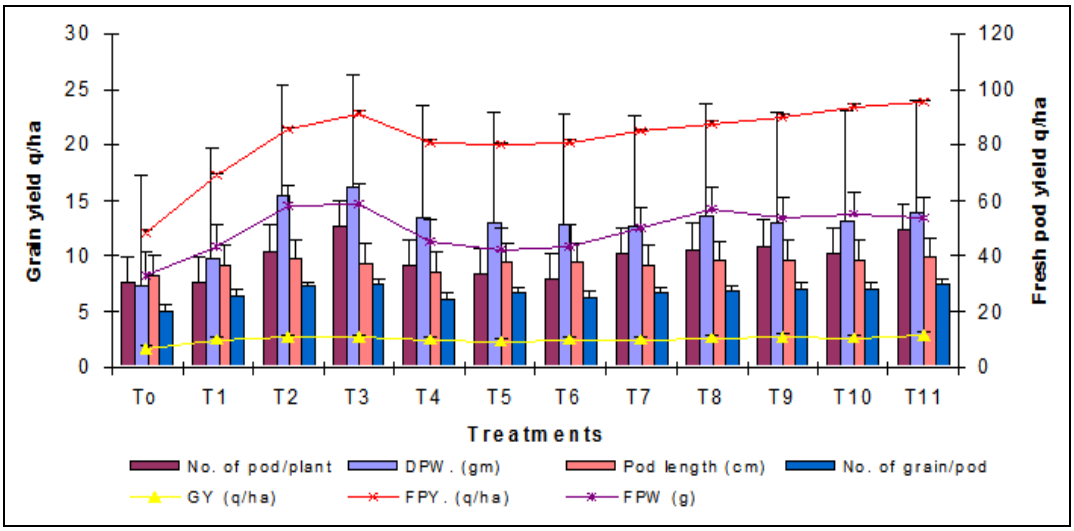

Fig 1: Effect of inorganic module on yield attributes

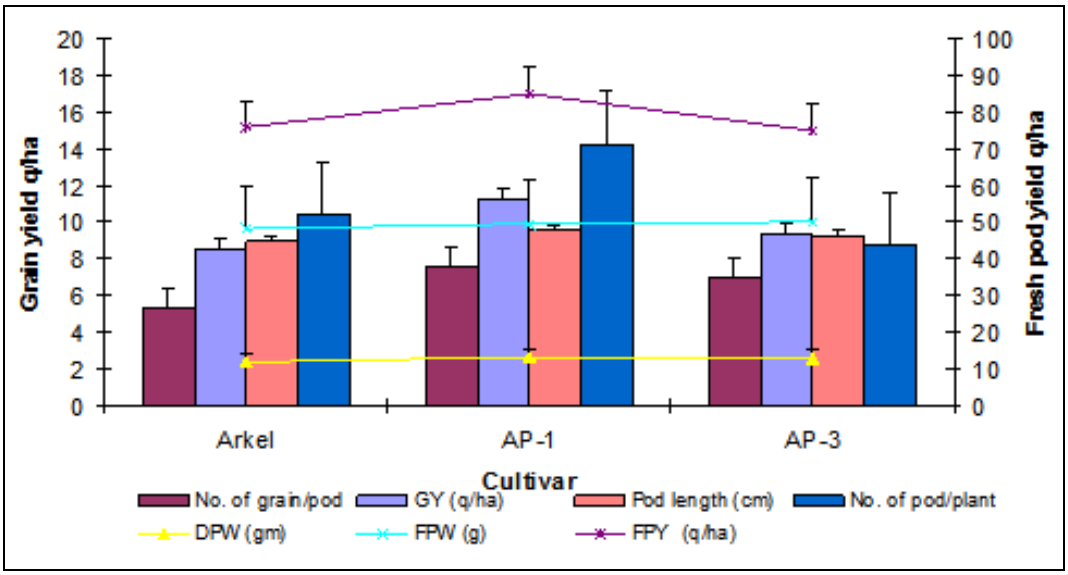

Fig 2: Effect of genotype on yield attributes

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