International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2024; 12(2): 20-27

Received: 14-02-2024
Accepted: 14-03-2024

Anupam Agarwal
Research Scholar, Department of Chemistry, Institute of Basic Science, Bundelkhand University Jhansi, Uttar Pradesh, India

Dr. Satyavir Singh
Assistant Professor, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, India

Dr. Chitra Gupta
Co-ordinator, Department of Chemistry, Institute of Basic Science, Bundelkhand University Jhansi, Uttar Pradesh, India

Corresponding Author:
Anupam Agarwal
Research Scholar, Department of Chemistry, Institute of Basic Science, Bundelkhand University Jhansi, Uttar Pradesh, India

Effect of foliar application of water soluble metal (II) arginine phosphonitrile derivative containing essential elements on yield of pea (*Pisum sativum* L.)

Anupam Agarwal, Dr. Satyavir Singh and Dr. Chitra Gupta

Abstract
Micronutrients malnutrition is a global concern that affects more than two billion people world wide. It is an estimate of World Bank that India is one of the highest-ranking country in the world for the number of children suffering from malnutrition. Malnutrition refers to the situation where there is an unbalanced diet in which some nutrients are in excess, lacking or wrong proportions. There are various essential elements such as Calcium, Zinc, Magnesium, Iron and Copper required by organism in a small quantities to maintain health. A lot of work is going on worldwide to develop biodegradable polymers but most of them for organic polymers but inorganic Polymers in fact are very scarcely studied whereas these are multifunctional and biodegradable. In view of it some derivatives of one of the inorganic polymer phosphonitrilic chloride will be discussed. These inorganic materials are biodegradable and eco- friendly. This article is about to explain inorganic polymer for phosphonitrile derivatives (PNC) can carry variety of such micronutrients on its side chain as pendant groups. Pea (Pisum sativam) is a nutritious pulse crop with potential to assist in tackling hidden hunger. Here we report that yield and quality of pea crop can be enhanced by foliar spray of these phosphonitrile derivatives. Experimentally it have been observed and result shows that Phosphonitrile derivatives are going good for this. The present investigation entitled "Effect of foliar application of water soluble Metal (II) Arginine Phosphonitrile derivative containing essential elements on yield of Pea (*Pisum sativum* L.)" was conducted at the Organic Research Farm, Karguanji , Department of Chemistry, Institute of Basic Science, Bundelkhand University Jhansi (U.P.) during the year 2020-21 Ravi season. The experiment was comprised of with sixteen treatments which were laid out in Randomize Block Design with three replication. Result showed that the quality parameters like no. of pod, no. of seeds and yield of the crop was recorded maximum in treatment with PNC (T_9 to T_{16}) comparision to treatments with NPK (T_1 to T_8). However, all quality parameters are noticed minimum in treatment T_0 (Control). There was a positive linear relationship between growth/yield and Metal (II) Arginine phosphonitrilic derivatives. The best yield was obtained with T16 hence this was recommended for the production of pea in the study area.

Keywords: Foliar application, micronutrients, metal (ii) arginine phosphonitrilic derivatives, pea (*Pisum sativum* L.)

Introduction
Micronutrients malnutrition is a global concern that affect more than two billion people worldwide (WHO) [1]. India is one of the highest ranking country in the world for the number of children suffering from malnutrition. The prevalence of underweight children in India is among the highest in the world. In India 44% of children under the age of 5 are underweight, 72% of infants and 52% of married women are anaemic. Research shown that malnutrition during pregnancy causes the child to have risk of future diseases, physical retardation and reduced cognitive abilities. (Synopsis 2) [2]. The malnutrition is the result of insufficient intake of micronutrients through staple foods. This problem is due to insufficient intake of micronutrients through staple foods. Micronutrients are essential elements required by human beings in small quantities throughout life to maintain health. Micronutrients are various essential elements such as Ca, Zn, Mg, Fe and Cu required by organism in small quantities to maintain health.

Plant foods remains the major source of micronutrients for the poor in developing countries since animal products, which are rich in micronutrients, are beyond their reach. Micronutrient nutritional quality is important in addressing the global issues of "hidden hunger" and can lead

to a variety of health complications. Most of micronutrients are either used as such or sometimes attached with polymers. Diets deficient in micronutrients raise the risk for blindness, lower IQ and immune deficiencies. Strategies for reducing the prevalence of micronutrient malnutrition have primarily focused on encouraging people to take dietary supplements, to increase diversity in their diets, and to fortify foods during processing (Sharma et al. 2017) [3].

Pea *(Pisum sativum L.)* is a nutritious pulse with potential to assist in tackling hidden hunger. Pea *(Pisum sativum L.)* is the third most important food legume in the Fabaceae family (FAOSTAT) [4]. Pea (*Pisum sativum* L.) is one of the most important pulse crops among the various grain legumes grown in India and second most important legume crop of the world (Pawar *et al.* 2017) [5]. According to Vavilov (1951) [6], it is native to Mediterranean region of Southern Europe & Western Asia; belong to the family Leguminaceae (Sub. family Papilionaceae) is cool season nutritive vegetable crop. This legume contain high percentage of digestible protein (7.2 g), carbohydrates (15.8 g), vitamin A (139 I.U.), vitamin C (9 mg), magnesium (34 mg), phosphorus (139 mg) and essential amino acids per 100 g of edible portion (Gopalan *et al.* 2007) [7]. It can be consumed either fresh, canned, pulse, frozen or in dehydrated forms. Peas are grown worldwide, incorporated into human diets as fresh, processed or dried vegetables. This crop and it's by products can also be used as fodder. It is used as green manure as well (Makasheva, 1983) [8].

Peas are grown worldwide, incorporated into human diets as fresh, processed, or dried vegetable, and also used as a forage crop for animals. Pea seeds are excellent sources of proteins, dietary fibre, and mineral nutrients (Iqbal et al., 2006) [9] and (Grela et al. 2017) [10]. Consumption of pulses, including peas, can help reduce risk of cancer and cardiovascular disease (Mudryj et al., 2014) - and (Poblaciones et al. 2018) [12]. Additionally, including peas in the diet can help manage diabetes by regulating blood glucose and insulin levels (Mudryj et al. 2014) [11]. Pea seed protein is unlikely to cause allergenic reactions and easily digestible (Day L.,2013) [13].

Plant foods remains the major source of micronutrients for the poor in developing countries since animal products, which are rich in micronutrients, are beyond their reach. Micronutrient nutritional quality is important in addressing the global issues of "hidden hunger" and can lead to a variety of health complications. Most of micronutrients are either used as such or sometimes attached with polymers.

In world major green pea cultivated countries China, India, United States of America, France, Egypt, Pakistan, Peru, Algeria, United Kingdom Russian and Federation. In India, the pea occupies 575 thousand hectares with production of 5855 thousand tonnes (Anon., 2021a) [14]. Major pea cultivated states is Uttar Pradesh, Jharkhand, Punjab, West Bengal, Haryana, Andhra Pradesh, Bihar, Uttarakhand, Madhya Pradesh, and Himachal Pradesh, where it is grown for both vegetable and pulse purposes and is a highly remunerative crop (Singh *et al.*, 2005) [15]. The plant nutrition is one of the most important factors responsible for the proper growth and development of the plants. The imbalanced and inadequate fertilizers use and coupled with low efficiency of chemical fertilizers declined tremendously under intensive cultivation in recent years. Variation in nutrients supply is a natural phenomenon and some of them may be sufficient where others deficient. The methods of nutrient application play an important role in supplying the nutrients to the plants. Soil application is most common method to supply essential nutrients to plants. In this case applied nutrients are absorbed by plant roots but the efficacy of fertilizers applied in soil being low due to various losses and fixations. Foliar nutrition is designed to eliminate the above problems (Chaurasia *et al.*, 2005; Fageria *et al.*, 2009) [16, 17]. With regard to the historical origin of foliar nutrition or foliar feeding, it has been documented as early as 1844. Foliar fertilization, recently, has been widely used and accepted as an essential part of crop production like horticultural crops. This method of application has mainly been used where nutrients are required in only small amounts or when a quick plant response to fertilizer is desired (Kolota and Osinska, 1999) [18]. Foliar feeding with macro and micronutrients are more effective in terms of attaining maximum yield and reduction in losses, when plant crops are cultivated in micronutrient deficient soils, they possess low micronutrients content and consequently low bioavailability (Manea *et al.*, 2019) [19]. Micronutrients are usually required in minute quantities, nevertheless are vital to the growth of plant. Application of micronutrients is less expensive but can give higher profits than other nutrients (Solanki *et al.*, 2010) [20]. So keeping above facts its urgent need to identify the most appropriate combination of foliar feeding macro and micronutrients and its effects to increase yield as well as economic of pea cultivation under conditions of Jhansi for higher production and for commercial applications to the farmers of this region. Hence, looking to the above facts, the present investigation entitled "Effect of foliar application of water soluble Metal (II) Arginine Phosphonitrile derivative containing essential elements on yield of Pea (*Pisum sativum* L.)" is being proposed.

Therefore this study was carried out to determine the effects of foliar sprey of such phosphonitrile derivatives (PNC) having plant nutrients itself comparison to NPK on the growth /yield of Pea in the study area.

Materials and Methods

The present experiment was conducted at organic research farm Karguan Ji of Bundelkhand University, Jhansi (Uttar Pradesh). This farm is situated behind the Bundelkhand University in foot hills of Kamashan Mata Temple during *Rabi* season of year 2020-21 and 2021-22 with vegetable pea cultivar Arkel.

Experimental Site and Soil

The field experiment was laid out on newly developed plot, a part of organic research farm Karguan Ji of Bundelkhand University, Jhansi (Uttar Pradesh). This farm is situated behind the Bundelkhand University in foot hills of Kamashan Mata Temple. Geographically, the Karguwa Ji Farm of Bundelkhand University, Jhansi is situated at a 25^0.27'03.2 North latitude and 780.36'48.4" E longitude. The attitude level of Bundelkhand University Jhansi plains is about 257m above mean sea level.

Test Crop

The variety ARKEL was used as the test crop and the seeds were collected from Krishi Vigyan Kendra (KVK), Jhansi.

Land preparation

The land was prepared by ploughing and cross ploughing with a power tiller. Ploughed soil was brought into desirable fine tilth by ploughing and cross-ploughing, harrowing, and laddering. The stubble and weeds were removed. Experimental land
was divided into unit plots following the experimental design.

Experimental Design and Layout
The experiment was laid out with 17 treatment in randomized block design (RBD) with three replications. The entire experiment area was divided into 17 plots. The unit plot size was 1.25 m x 1.25 m; the plots were separated from each other by 30 cm spaces. The treatments were randomly distributed.

Treatments
There were 17 treatments including one control treatment. All the phosphonitrile derivatives treatment were done as foliar application on the flower with the help of sprey method. The treatment combinations for the experiment were as follows -

Table 1. Treatments Combination with their Symbols.

S. No.	Symbols	Treatments
1.	T_0	Control
2.	T_1	Foliar Spray of NPK @ 1%
3.	T_2	Foliar Spray of NPK @ 2%
4.	T_3	Foliar Spray of NPK @ 3%
5.	T_4	Foliar Spray of NPK @ 10%
6.	T_5	Foliar Spray of NPK @ 15%
7.	T_6	Foliar Spray of NPK @ 20%
8.	T_7	Foliar Spray of NPK @ 25%
9.	T_8	Foliar Spray of NPK @ 30%
10.	T_9	Foliar Spray of PNC @1%
11.	T_{10}	Foliar Spray of PNC @2%
12.	T_{11}	Foliar Spray of PNC@3%
13.	T_{12}	Foliar Spray of PNC @10%
14.	T_{13}	Foliar Spray of PNC @15%
15.	T_{14}	Foliar Spray of PNC @20%
16.	T_{15}	Foliar Spray of PNC @25%
17.	T_{16}	Foliar Spray of PNC @30%

Seed Treatment
The collected seeds from KVK were dipped into water for a night to enhance emergence. Then the seeds were treated with *Rhizobium* culture.

Sowing of Seeds
The seeds were sown @ 2−3 seeds per hill on 5th November 2020, in furrows at a depth of 3−5 cm with the spacing of 30 cm X 15 cm.

Intercultural and other Operations
Seeds started germination four days after sowing (DAS). Thinning was done two times; the first thinning was done at 8 DAS and the second was done at 15 DAS to maintain optimum plant population in each plot. Just after sowing, light irrigation was given for quick seedling emergence after that two irrigation was given during flowering and pod maturity. The crop field was weeded as necessary. There was no infestation of insect pests and diseases in the field during the experimental period and no control measures were adopted. Four plants from each treatment were randomly selected and marked with a sample card. Plant height and number of branches were recorded from selected plants at an interval of 15 days started from 65 DAS (days after sowing) to harvest period.

Harvesting
Harvesting was done when 90% of the pods became mature. The matured pods were collected by hand picking.

Data collection
The following data were recorded- Plant height (cm), No. of branches per plant, No. of pods per plant, Pod lengh (mm per pod), Pod breadth (mm per pod), No. of seeds per pod, 100 Seeds weight (g), Pod weight (g per pod), Pod Yield (1 per ha), Seed Yield (t per ha).

Result and Discussion
The findings of the experiment have been presented and discussed with the help of table and possible interpretations were given under the following headings:

Plant Height (cm)
Plant height of Arkel was significantly influenced due to foliar application of NPK and water soluble Metal (II) Arginine Phosphonitrilic derivatives in different concentrations (Table 2). Plant height was measured at 30, 60 and 90 DAS. Plant height ranged from 11.46 to 27.58 cm at 30 DAS, 16.08 to 42.18 cm at 60 DAS and 22.54 to 52.36 cm at 90 DAS. The tallest plant of 27.58 cm was found in T_{16} (Foliar Spray of PNC @30%) at 30 DAS and the shortest plant of 11.46 cm was found inT_0 (control) at 30DAS. The tallest plant of 42.18 cm was found in T_{16} (Foliar Spray of PNC @30%) at 60 DAS and the shortest plant of 16.08 cm was found inT_0 (control) at 30 DAS. The tallest plant of 52.36 cm was found in T_{16} (Foliar Spray of PNC @30%) at 90 DAS and the shortest plant of 22.54 cm was found inT_0 (control) at 90DAS. Increase in plant growth might be due to hastened meristematic activities, better root growth and better absorption of nutrients (Singh et al., 1980) [21] under different nutrient sources (NPK & PNC) in the early stage of the life cycle. The highest plant height was recorded when grown with the application of Foliar Spray of PNC @30% and significantly lowest plant height was recorded when grown with the application of no nutrient sources. The plant height gradually increases. These findings are an agreement with the findings of (Naidu et al. 2001) [22] and (Singh et al. 2003) [23] in pea. It indicated that the varying level of fertilizer package increased the plant height. (Sheikh 1997) [24] and Anjum and Amjad (1999) [25] obtained similar plant height while working with fertilizer levels in garden pea. The present results are in agreement with their findings. Pandita and Pratap (1986) [26] found similar results in plant height of pea by using different fertilizer.

Table 2: Plant Height of Garden Pea at Different DAS Under Different Treatments

Treatments	Plant Height(cm)		
	30 DAS	60DAS	90DAS
T0	11.46	16.08	22.54
T1	12.74	18.88	23.22
T2	14.04	20.23	25.11
T3	14.58	22.72	27.22
T4	15.11	23.35	29.15
T5	15.92	24.11	30.53
T6	16.03	26.41	31.26
T7	16.32	27.21	33.06
T8	17.04	28.02	34.13
T9	17.33	29.66	35.69
T10	17.85	30.98	36.06
T11	18.04	31.45	37.26
T12	18.06	31.56	38.14
T13	18.77	32.33	39.52
T14	19.11	34.09	41.41
T15	22.45	35.78	44.32
T16	27.58	42.18	52.36
C.D.(5%)	2.596	1.613	2.135
SE(m)	0.897	0.557	0.738
SE(d)	1.269	0.788	1.043
C.V	9.049	3.454	3.739

Number of Branches Per Plant

Number of branches (primary) per plant increased significantly at all the growth stages as result of Foliar Spray of PNC @30% (Table 3). The branches were counted from 45 DAS at 15 days interval at 60 DAS, and it was finished at 90 DAS. At 45 DAS, the maximum number of branches per plant (1.41) was recorded under treatment T_{16} (Foliar Spray of PNC @30%) and the minimum number of branches per plant (1.04) was found under treatment T_0 (Control).

Similarly, the maximum number of branches per plant (1.53) at 60 DAS was recorded under treatment T_{16} as against the minimum number of branches per plant (1.07) under treatment T_0. The maximum number of braches per plant (1.62) was recorded at 90 DAS under treatment T_{16} and minimum number of branches per plant (1.11) under treatment T_0. The highest number of braches per plant (1.62) was recorded at 90 DAS under treatment T_{16} among the data which was significantly higher than others.

Table 3: No. of Branches Per Plant of Pea at Different DAS

Treatments	No. of Branches		
	45DAS	60DAS	90DAS
T_0	1.04	1.07	1.11
T_1	1.09	1.12	1.16
T_2	1.11	1.15	1.19
T_3	1.12	1.17	1.21
T_4	1.13	1.19	1.24
T_5	1.15	1.23	1.27
T_6	1.18	1.24	1.31
T_7	1.19	1.27	1.33
T_8	1.2	1.3	1.37
T_9	1.21	1.33	1.39
T_{10}	1.23	1.37	1.44
T_{11}	1.24	1.38	1.47
T_{12}	1.27	1.41	1.51
T_{13}	1.31	1.44	1.54
T_{14}	1.34	1.47	1.57
T_{15}	1.38	1.49	1.59
T_{16}	1.41	1.53	1.62
C.D.(5%)	0.076	0.091	0.041
SE(m)	2.026	0.031	0.014
SE(d)	0.037	0.045	0.02
C.V.	3.734	4.173	1.803

Number of Pods per Plant

Number of pods per plant is an important factor among the yield contributing characters. Foliar application of NPK and water soluble Metal (II) Arginine Phosphonitrilic derivatives in different concentrations of statistically significant variation on number of pods per plant of Arkel (Table 4). The maximum number of pods per plant (7.45) was recorded at 45 DAS under treatment T_{16} (Foliar Spray of PNC @30%) and the minimum number of pods per plant (2.86) was found at 45 DAS under treatment T_0 (Control).

While after 60DAS, the maximum number of pods per plant (7.68) was recorded under treatment T_{16} (Foliar Spray of PNC @30%) whereas the minimum number of pods per plant (3.46) was found under treatment T_0 (Control). The maximum number of pods per plant (8.44) was recorded at 90 DAS under treatment T_{16} (Foliar Spray of PNC @30%) which was superior over other treatments whereas the minimum number of pods per plant (3.87) was found at 45 DAS under treatment T_0 (Control). The results are in agreement with Rao et. al. (1994**)** [27].

Table 4: Number of Pods Per Plant of Pea at Different DAS

Treatments	No. of Pods per Plant		
	45DAS	60DAS	90DAS
T_0	2.86	3.46	3.87
T_1	3.14	3.57	3.98
T_2	3.59	3.62	4.12
T_3	3.82	3.87	4.28
T_4	4.11	3.98	4.32
T_5	4.29	4.21	4.41
T_6	4.32	4.42	4.62
T_7	4.47	4.64	4.76
T_8	4.5	4.88	5.14
T_9	5.24	5.32	5.47
T_{10}	5.51	5.64	5.87
T_{11}	6.21	6.37	6.54
T_{12}	6.54	6.69	6.85
T_{13}	6.92	7.05	7.24
T_{14}	7.14	7.31	7.55
T_{15}	7.29	7.41	7.86

T_{16}	7.45	7.68	8.44
C.D.(5%)	0.108	0.074	0.066
SE(m)	0.037	0.025	0.023
SE(d)	0.053	0.036	0.032
C.V.	1.26	0.832	0.7.04

Pod Length (mm Per Pod)

Statistically significant variation was recorded due to Foliar application of NPK and water soluble Metal (II) Arginine Phosphonitrilic derivatives in different concentrations in terms of pod length of Arkel (Table 5). The maximum pod length ((58.34 mm) was recorded under treatment T_{16} (Foliar Spray of PNC @30%) and the minimum pod length (34.15 mm) was found under treatment T_0 at 45DAS. After 60 days, the maximum pod length ((59.12mm) was recorded under treatment T_{16} (Foliar Spray of PNC @30%) whereas the minimum pod length (36.11 mm) was found under treatment T_0. The maximum pod length ((61.25mm) was recorded under treatment T_{16} (Foliar Spray of PNC @30%) and the minimum pod length (37.21 mm) was found under treatment T_0 at 90DAS. Hoque (1987) [28] reported that there was an insignificant relationship in pod length in mungbean. However, the longer pod length was recorded with the foliar application of water soluble Metal (II) Arginine Phosphonitrilic derivatives in different concentrations and minimum with the application of NPK.

Table 5: Pod Length of Pea at Different DAS

Treatments	Pod Length (mm per Pod)		
	45DAS	60DAS	90DAS
T_0	34.15	36.11	37.21
T_1	37.23	38.12	39.45
T_2	39.02	40.22	41.25
T_3	41.15	42.31	43.27
T_4	42.36	44.22	46.32
T_5	44.15	46.11	47.21
T_6	45.26	47.32	48.27
T_7	46.53	48.54	49.35
T_8	47.21	49.85	51.23
T_9	48.02	50.05	52.11
T_{10}	50.11	51.78	53.26
T_{11}	52.03	53.11	54.12
T_{12}	54.26	56.06	57.91
T_{13}	55.13	56.64	58.66
T_{14}	56.65	57.23	59.23
T_{15}	57.19	58.87	60.27
T_{16}	58.34	59.12	61.25
C.D.(5%)	1.326	1.505	1.212
SE(m)	0.458	0.52	0.419
SE(d)	0.648	0.736	0.593
C.V.	1.656	1.833	1.435

No. of Seeds Per Pod

Statistically significant variation was recorded due to the effect of foliar application of NPK and water-soluble Metal (II) Arginine Phosphonitrilic derivatives in different concentrations on the number of seeds per pod of Arkel (Table 7). The maximum number of seeds per pod (5.44) was observed from T_{16} (Foliar Spray of PNC @30%) and the minimum number (2.74) was found from T0 at 45 DAS. After 60 days, the maximum number of seeds per pod (5.57) was observed from T_{16} (Foliar Spray of PNC @30%) and the minimum number (3.19) was found from T0 whereas after 90 DAS completion, the maximum number of seeds per pod (5.62) was observed from T_{16} (Foliar Spray of PNC @30%) and the minimum number (3.51) was found from T_0. Thirapom (1992) [29] obtained similar results while working with maize. From the present experiment among different growing conditions, the higher number of seeds per pod were recorded with the foliar application of water soluble Metal (II) Arginine Phosphonitrilic derivatives in different concentrations and lower number of seeds per pod were recorded from NPK.

Table 7: No. of Seeds Per Pod of Pea at Different DAS

Treatments	**NO. of Seeds per Pod**		
	45DAS	**60DAS**	**90DAS**
T_0	2.74	3.19	3.51
T_1	2.97	3.31	3.78
T_2	3.01	3.45	3.95
T_3	3.14	3.59	4.07
T_4	3.19	3.87	4.09
T_5	3.21	4.01	4.15
T_6	3.24	4.11	4.3
T_7	3.27	4.14	4.34
T_8	3.36	4.21	4.39
T_9	3.45	4.24	4.42
T_{10}	3.49	4.33	4.49
T_{11}	4.07	4.47	4.57
T_{12}	4.42	4.74	5.03
T_{13}	4.68	4.89	5.17
T_{14}	4.87	5.17	5.24
T_{15}	5.19	5.32	5.39
T_{16}	5.44	5.57	5.62
C.D.(5%)	0.098	0.058	0.066
SE(m)	0.034	0.02	0.023
SE(d)	0.048	0.028	0.032
C.V.	1.557	0.815	0.885

Seeds Weight (g)

From the observation, it was found that the 100 seeds weight differed significantly from one treatment to another (Figure 1). 100 seeds weight ranged from 15.9 to 29.34 g. The highest 100 seed weight (29.34 g) was found in T_{16} (Foliar Spray of PNC @30%) and the lowest weight (15.9 g) was obtained from T_0 (Control) because the plants grew small seeds. The size of seeds of T_{16} plants were larger than that of others.

Treatment	**Seed Weight**	**Pod Yield**	**Seed Yield**
T_0	15.9	1.71	1.11
T_1	17.3	1.94	1.23
T_2	19.18	2.04	1.34
T_3	19.55	2.34	1.59
T_4	20.24	2.49	1.65
T_5	21.33	2.77	1.89
T_6	21.53	2.94	2.01
T_7	22.04	3.11	2.25
T_8	22.34	3.18	2.31
T_9	22.95	3.25	2.69
T_{10}	23.78	3.59	2.97
T_{11}	24.15	3.97	3.28
T_{12}	25.52	4.41	3.69
T_{13}	26.12	5.07	4.04
T_{14}	27.44	5.78	4.58
T_{15}	28.47	6.17	5.14
T_{16}	29.34	6.84	5.57

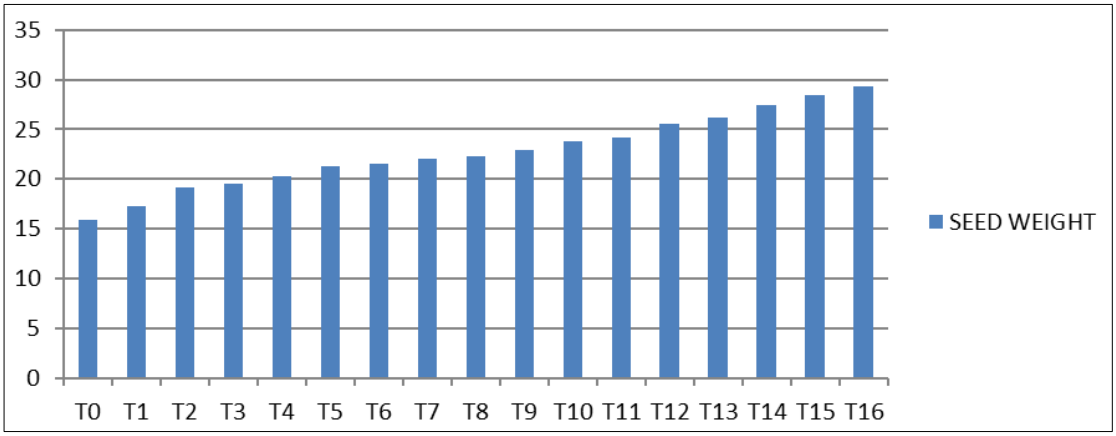

Fig 1: Seed weight

Pod Weight (g Per Pod)

The pod (fresh) weight varied greatly for different treatments and different harvesting time. Table 8 indicates that maximum pod weight (2.69 g) was recorded under treatment T_{16}(Foliar Spray of PNC @30%) at 90 DAS which was found superior over other treatments, whereas the minimum pod weight(2.01 g) was found under treatment T_0 (Control) at 45 DAS. The weather prevailed during this time was perhaps favorable for the maximum vegetative growth of T_{16} plants and lead to production of higher photosynthetic products which result in maximum pod weight. These findings are supported by Sachan et al. (2003) [30].

Table 8: Pod Weight of Garden Pea at Different DAS

Treatments	Pod Weight of Pea		
	45DAS	60DAS	90DAS
T_0	2.01	2.07	2.11
T_1	2.04	2.09	2.13
T_2	2.06	2.12	2.17
T_3	2.08	2.15	2.21
T_4	2.11	2.17	2.24
T_5	2.13	2.22	2.29
T_6	2.15	2.23	2.31
T_7	2.17	2.25	2.34
T_8	2.21	2.29	2.37
T_9	2.27	2.37	2.49
T_{10}	2.34	2.46	2.59
T_{11}	2.43	2.54	2.67
T_{12}	2.54	2.67	2.82
T_{13}	2.67	2.79	2.93
T_{14}	2.8	2.93	3.07
T_{15}	2.94	3.06	3.22
T_{16}	3.08	3.21	3.39
C.D.(5%)	0.059	0.057	0.058
SE(m)	0.02	0.02	0.02
SE(d)	0.029	0.028	0.028
C.V.	1.492	1.384	1.365

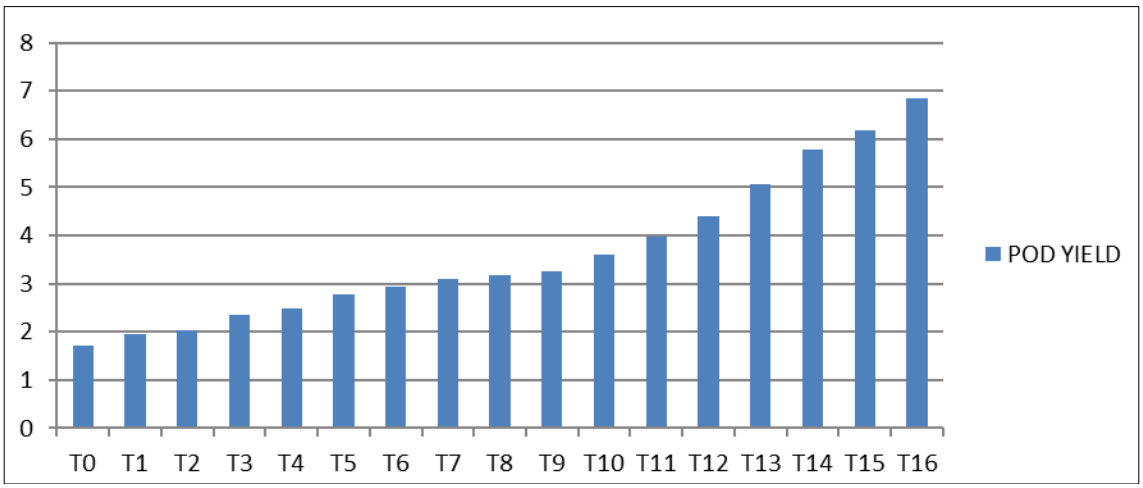

Fig 2: Pod Yield

Pod Yield (ton per ha)

Figure 2 indicates that maximum pod yield per ha (6.84 t), recorded under treatment T_{16} (Foliar Spray of PNC @30%), was found superior over other treatments whereas the minimum pod yield per ha (1.71 t) was found under treatment T_0 (control). The unusually foggy weather prevailed during 2020−21 resulting in inferior yield contributing parameters and as such lower green pod yield. These findings are supported by Sachan et al. (2003) [30] and Chandra and Polisetty (1998) [31].

Seed Yield (ton per ha)

Seed yield is the additive result of the yield contributing characters of pea. The goal of raising crop is to increase the yield. The effect of different treatments on the seed yield of pea was evaluated and the findings are presented in Figure 3.

It was found that the seed yield due to foliar application of water soluble Metal (II) Arginine Phosphonitrilic derivatives in different concentrations ranged from 1.11 to 5.57 t per ha. The highest seed yield (5.59 t per ha) was recorded in T_{16} (Foliar Spray of PNC @30%) and the lowest value (1.11 t per ha) was recorded in T_0 (control) The seed yield upto T_8 (Foliar Spray of NPK @ 30%) are very poor in the comparision to the treatments from T_9 to T_{161} (Foliar Spray of PNC@30%). (Figure 3). The increase in seed yield with the application of inorganic fertilizers might be due to the greater synthesis and partitioning of metabolites. The sink size improved significantly as reflected by more number of seeds per pod. There was overall elasticity in sink with the higher levels of PNC. These finding are corroborations of the results of Akhter et al. (1998) [32].

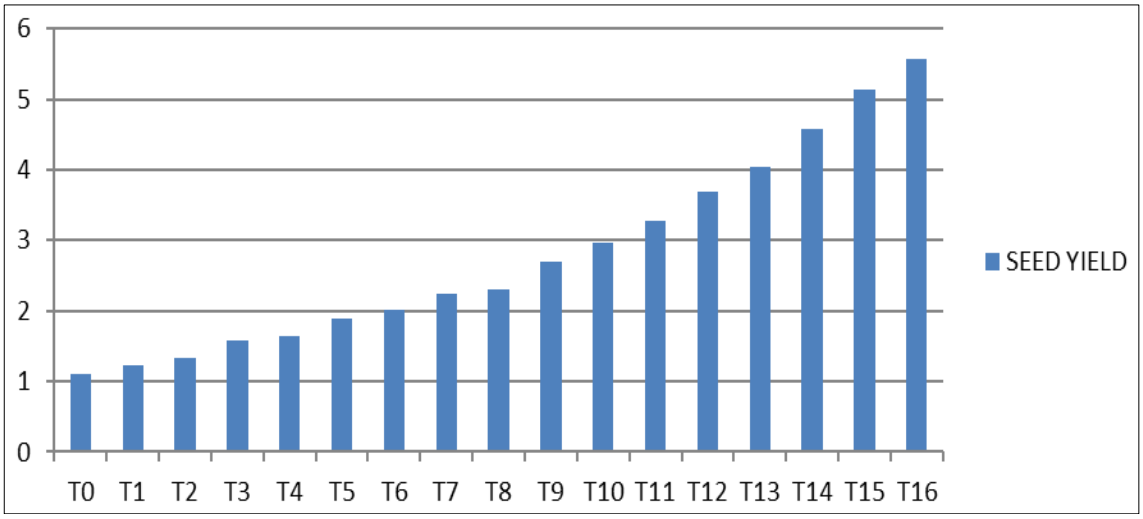

Fig 3: Seed Yield

Conclusion and Recommendation

There were significant differences in yield parameters due to concentration varying treatments of Metal (II) Arginine Phosphonitrilic derivatives in different concentrations, yield parameters increased with increased concentration of PNC. Zero PNC derivatives application (control) gave th**e** Least values, while Foliar Spray of PNC@30 application gave the highest values in terms of yield of Pea. The best yield was obtained with T_{16}. Thus it can be concluded that farmers need to apply these Metal (II) Arginine phosphonitrile derivatives, for getting more number of pods/ plant and optimum yield of Pea.

It is therefore recommended that for the cultivation of Pea in this study area, 30% concentration of Metal (II) Arginine phosphonitrile derivatives is required and should be used.

References

1. WHO. Guidelines on food fortification with micronutrients. World Health Organisation, Geneva; c2006.
2. Varma S. Superpower? 230 million Indians go hungry daily. The Time of India; c2012 Jan 15. Available from: http://articles.timesofindia.com/2012-01-15/india/30629637_1_anganwadi-workers-ghi-number-of-hungry-people
3. Sharma P, Aggarwal Sachdev P, Kaur A. Biofortification: A new approach to eradicate hidden hunger. Food Reviews International. 2016 May;33(1):1-21. DOI: 10.1080/87559129.2015.1137309.
4. FAOSTAT. FAO statistical databases. Food and Agriculture Organization of the United Nations, Rome; c2019.
5. Pawar Y, Verma LR, Verma P, Joshi HN, More SG, Dabhi JS. Influences of integrated use of organic and inorganic sources of nutrients on growth, flowering and yield of garden pea (*Pisum sativum* L.) cv. Bonneville. Legume Research. 2017;40(1):117–124.
6. Vavilov NI. The origin, variation, immunity and breeding of cultivated plants. L.W.W. 1951;72(6):482.
7. Gopalan C, Rama SBV, Balasubramanian SC. Nutritive Value of Indian Foods. Revised Edition. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India; c2007. p. 50.
8. Makasheva RK. The Pea. Translated from Russian by B.R. Sharma. Oxonian Press, New Delhi, India; c1983. p. 267.
9. Iqbal A, Khalil IA, Ateeq N, Khan MS. Nutritional quality of important food legumes. Food Chem. 2006;97:331-335.
10. Grela ER, Kiczorowska B, Samolinska W, Matras J, Kiczorowski P, Rybinski W, *et al.* Chemical composition of leguminous seeds: part I- content of basic nutrients, amino acids, phytochemical compounds, and antioxidant activity. Eur Food Res Technol. 2017;243:1385-95.
11. Mudryj AN, Yu N, Aukema HM. Nutritional and Health benefits of pulses. Applied Physiology, Nutrition, and Metabolism; c2014. p. 1197-1204. DOI: 10.1139/apnm-2013-0557.

12. Poblaciones MJ, Rengel Z. The effect of processing on *Pisum sativum* L. biofortified with sodium selenate. Journal of Plant Nutrition and Soil Science. 2018;181:932-937.
13. Day L. Proteins from land plants-potential resources for human nutrition and food security. Trends in Food Science & Technology. 2013;32:25-42.
14. Horticultural Statistics at a Glance. Horticulture Statistics Division, Department of Agriculture, Co-operation & Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India; c2021.
15. Singh C, Singh P, Singh R. Modern technique of raising field crops. Ox and Public Co. Pvt. Ltd., New Delhi, India. Second Edition. 2005;220.
16. Chaurasia SNS, Singh KP, Rai M. Effect of foliar application of water soluble fertilizers on growth, yield and quality of tomato (*Lycopersicon esculentum* L.). Sri Lankan Journal of Agricultural Sciences. 2005;42:66-70.
17. Fageria NK. The use of nutrients in crop plants. CRC Press, Boca Raton, c2009.
18. Kolota E, Osinska M. Efficiency of foliar nutrition of field vegetables grown at different nitrogen rates. In International Conference on Environmental Problems Associated with Nitrogen Fertilisation of Field Grown Vegetable Crops, 1999;563:87-91.
19. Manea AI, AL-Bayati HJ, AL-Taey DKA. Impact of yeast extract, zinc sulphate and organic fertilizers spraying on potato growth and yield. Res. on Crops. 2019;20(1):95-100.
20. Solanki VPS, Singh SP, Singh OV, Singh V. Differential response of vegetable crops to zinc fertilization in alluvial soils. Indian Journal of Agricultural Sciences. 2010;80(12):1054-1057.
21. Singh RB, Singh D, Singh DN. Response of field pea to population density and phosphorus levels. Indian Journal Plant Physiology. 1980;23(2):185−191.
22. Naidu AK, Kushwah SS, Mehta AK, Jain PK. Study of organic, inorganic and biofertilizers in relation to growth and yield of tomato. Jawaharlal Nehru Krishi Vishwa Vidyalaya Respective Journal. 2001;35:36−37.
23. Singh R, Singh SS. Response of seed yield of garden pea (*Pisum sativum*) to various seed rate and fertility. Journal of Vegetation Science. 2003;30:71-73.
24. Sheikh MA. Effect of various levels of nitrogen on vegetative growth and flower production of gladiolus [Master's thesis]. Tandojam, Sindh, Pakistan: Sindh Agricultural University; c1997.
25. Anjum MA, Amjad M. Response of okra (*Abelmoschus esculentus* L. Moench) to different levels of N, P and K fertilizers. Pakistan Journal of Biological Sciences. 1999;2(3):794-796.
26. Pandita ML, Pratap PS. In vegetable crop, pea and beans. In: Bose TK, Som MG, Kabir J, eds. Naya prokash, 206, Bidhan sarani, Calcutta, India; c1986. p. 549-580.
27. Rao VP, Raikhellar SV, Sondge VD. Nutrient uptake and fertilizer use efficiencies in sesame (*Sesamum indicum* L.) as influenced by irrigation and fertilization. Annals of Agricultural Research. 1994;15:280-285.
28. Hoque MM. Effect of different plant population on the growth and yield of mungbean [*Vigna radiata* L. Wilczek] [Master's thesis]. Mymensingh: Department of Agronomy, Bangladesh Agricultural University; c1987.
29. Thirapom R, Feil E, Stemp P. Effect of nitrogen fertilization on grain yield and accumulation of N, P, and K in grains of tropical maize. Journal of Agronomy and Crop Science. 1992;9:9-16.
30. Sachan CP, Yadav MP, Katiyar PK, Sanjeev K, Kanaujia VP. Effect of harvest time on seed quality in pea. Journal of Farm Sciences. 2003;12(1):64-66.
31. Handra R, Polisetty R. Factors affecting growth and harvest index in pea (*Pisum sativum* L.) varieties differing in time of flowering and maturity. Journal of Agronomy and Crop Science. 1998;181(3):129-135.
32. Akhtar S, Farid ATM, Shil NC, Rahman M. Effect of different fertilizers on nodulation and yield of cowpea. Legume Research. 1998;21:74-78.