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Studies on the effect of culture, liquid and capsulated biofertilizer on yield attributes of vegetable pea (*Pisum sativum* L.) cv. Kashi Nandini

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Abstract
The experiment was conducted at the farm of Research cum Demonstration Farm, DKS, CARS, Bhatapara, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the *rabi* seasons of 2019-20 and 2020-21. The yield parameters like pod length, number of pods per plant, number of seeds per pod, pod weight per plant, days to maturity, pod yield per plot, total pod Yield, shelling percent, harvest Index (%) were recorded significantly superior in the T13 (Rhizobium (Liquid)+ P.S.B. (Liquid) + 100% RDF), while remained at par treatments namely T12 (Rhizobium (Culture) + P.S.B.(Culture) + 100% RDF), T14 (Rhizobium (Capsulated) + P.S.B.(Capsulated)+100% RDF), T2 (RDF Only (25:50:50) NPK/ha) and T5 (Rhizobium (Capsule) +PK Supplied Through Fertilizer (0:50:50). The pooled data both years also revealed that among all the treatments, significant highest pod length (cm) (7.54), number of pods per plant (18.60), number of seeds per pod (9.25), were recorded in treatment T13 (Rhizobium (Liquid)+ P.S.B. (Liquid) + 100% RDF). And significantly highest pod weight per plant (gm) (84.25), the days taken earliest for maturity (75.00), pod yield per plot (kg) (3.90), total pod yield (qt ha-^{1}) (125.51) and shelling percent (53.05) were recorded in treatment in treatment T13 (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF).

Keywords: Yield parameters, rhizobium, fertilizer, seeds, pod yield, capsulated, RDF, P.S.B, shelling percent

1. Introduction
Vegetable pea (*Pisum sativum* L) is one of the fore most important versatile legume crop which is highly nutritious due to its important bio-chemical attributes protein content, protein quality (having a good amount of essential amino acids such lysine, methionine, leucine etc. which are not synthesized by the human body, minerals, oils and sugar content.
Pea is utilized mainly as a vegetable. Besides, it is also consumed as a pulse, in making soup, *dal*, *besan* concentrate and green fodder etc. The green peas can easily be canned, frozen and dehydrated. Pea is one of the most important sources of vegetable protein, pea enriches the soil, being a leguminous crop, it may not need much nitrogen, but an initial stage in the young plants before nodulation stage deficiency may exhibit and it may suffer due to nitrogen starvation, hence the small amount of inorganic nitrogen may stimulate early seedling growth and nodulation leading to an increase in the amount of nitrogen fixed in the plant. The imbalance of fertilization and terminal stress are responsible for the low productivity of the crop
In India 2020-21, the total area, production and productivity of pea is around 572.91 thousand ha, 5822.85 thousand tonnes and 10.16 million tonne per ha, respectively (Anonymous, 2020) [1]. Total pea production in Chhattisgarh 117.23 thousand tonnes from 8.65 thousand ha area and average productivity is 13.55 million tonne per ha which is far below to national productivity per ha (Anonymous, 2020) [1]. The dual seed inoculation with *Rhizobium* and PSB benefitted the plants by providing atmospheric N and rendering the insoluble phosphorus into available form. The enhanced availability of P favoured N fixation and the rate of photosynthesis. The Biofertilizer capsule of the invention comprises an effective amount of at least one agriculturally important microorganism and one or more carrier materials (Sahai and Chandra (2011) [8].

Biofertilizers a type of organic fertilizer is emerging as an ecologically safe means of fertilization. It is defined as a substance that contains living microorganisms when applied to seed, plant surfaces or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant (Vessey 2003) [14].

2. Materials and Methods

A field experiment was conducted at the farm of Research cum Demonstration Farm, DKSCARS, Bhatapara, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the *rabi* seasons of 2019-20 and 2020-21.

Bhatapara has a typical sub–humid to semi–arid climate and cold winter. The mean annual precipitation of this region is 1314.75 mm, of which nearly 85% is received during the monsoon period from mid-June to September, with brief showers in winter and summer season. The mean weekly temperature rises to 44 °C in the summer season and the minimum temperature falls as low as 8 °C during the winter month. The relative humidity (RH %) is high from June to October.

Composite soil samples from 0-20 cm depth were collected from ten randomly selected places with the help of soil auger from prior to start of the field experiment, to evaluate the nutrient status of the soil. Composite samples remain about 250 g and then it were used for analysis of the initial status of the physical and chemical properties of the soil. The soil of the experimental field was clay-loam in texture (*Inceptisol*) locally known as *"Dorsa"*. The soil was neutral in reaction. The available nitrogen, phosphorus and potassium content of the experiment site were low, medium and high, respectively.

The experiment was laid out in Randomized Block Design (RBD) with three replications. Fourteen treatments were allocated in each replication. The rhizobium and PSB culture were prepared by the standard method in which 200g 'gur' is dissolved in 1 ltr. of water. This solution 10 ml jaggery solution + 5 gm culture/kg seed and liquid rhizobium and PSB 10ml solution/kg seed was treated and this seeds was kept in shade dried for about 30 minutes for the completion of inoculation. Rhizobium and PSB culture & liquid are collected from the department of soil & microbiology, IGKV, Raipur. Nitrogen, phosphorus and potash were applied through urea, di- ammonium phosphate and muriate of potash, respectively.

The crop was harvested when the pod turned deep green and the pod were fully mature. At the time of harvesting, at first, the border rows were harvested around the individual plots leaving only net plot. The crop from net plots was harvested, separately and tagged.

3. Results and Discussion

The results obtained are discussed under the following heads and presented in Table 1 and Fig 1, 2, 3, 4, 5,.6, 7 and 8.

The mean data also revealed that among all the treatments, significant highest pod length (cm) (7.54) was noted in treatment T13 (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). Similar result was reported by Gupta *et al.* (2000) [6] reported that pod length, in pea significantly increased increase in the length, width, weight and yield of pod and shelling percentage of pea with the application of 80 kg P2O5 ha^{-1} along with 120 kg N ha^{-1} and bio-fertilizers. The results clearly collaborate with the finding of Singh and Singh (2003) [18] revealed that an application of 75 kg ha^{-1}, seed rate and medium fertility level of NPK (35:75:50 kg/ha) gave higher length of pod per plant of pea variety Azad P-1 and Narendra Sabzi Matar-2. Than the other levels of phosphorus (0, 20 and 60 kg P2O5 ha^{-1}).

It was also revealed from the mean data that among all the treatments, the significant highest number of pods per plant (18.60) was noted in treatment T13 (2003). Results corroborate the finding of Gupta *et al.* (2000) [6] reported that pod weight in pea significantly increased increase in the length, width, weight and yield of pod and shelling percentage of pea with the application of 80 kg P2O5 ha^{-1} along with 120 kg N ha^{-1} and bio-fertilizers.

It was also revealed from the mean data for significant highest days to maturity (83.05) was noted in treatment T1 (Control (no fertilizer apply)). The results obtained in the present study are supported by the works of Bhattarai *et al.* (2003) [2] reported that an application of low dose of chemical fertilizer (30:60:30 kg/ha) in combination with Rhizobium and PSB took minimum days in marketable maturity. Results corroborate the finding of Singh Pramod (2007) [11] reported that pea were increased by the application of low dose of chemical fertilizer (30:60:30 kg/ha) in combination with Rhizobium and PSB. NPK 30:60:30 kg/ha + Rhizobium + PSB took the minimum days in marketable maturity was observed in treatment NPK 30:60:30 + Rhizobium + PSB (67.66) which was significantly superior to all other treatments.

It was also revealed from the mean data that among all the treatments, the significant highest pod yield per plot (kg) (3.90) was noted in treatment T13 (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The favourable effect may be due to the fact that culture and liquid Rhizobium inoculation increased nitrogenase activity and also synthesis of growth promoting substances like indole acetic acid which take part in nodulation process and also influence vegetative growth. Thus, increase in nodulation, nitrogen fixation and synthesis of growth substances might have increase vegetative growth, yield and yield attributing characters. Similarly reported by Gavaskar (2020) [5].

It was also revealed from the mean data that among all the treatments, the significant highest total pod yield (qt ha^{-1}) (125.51) was noted in treatment T13 (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). Similar results were also reported by application of NPK has increased yield in comparison to control (no fertilizer apply). Yield is the outcome of a greater number of pods per plant, number of seeds per pod, pod weight per plant (gm) and pod yield per plot (kg) etc. Due to better growth, these parameters have been favorably increasing resulting in higher yield. Better vegetative and reproductive growth were observed in higher dose (recommended dose 40: 80: 40 kg/ha) resulting in higher yield. Similar findings were also reported by Sandhya (2019) [9] and Singh and Singh (2003) [13].

It was also revealed from the mean data that among all the treatments, the significant highest shelling percent (53.05) was noted in treatment T13 (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The results obtained in the present study is in accordance with the results of Gupta *et al.* (2000) [6] reported that shelling percentage of pea with the application of 80 kg P2O5 ha-1 along with 120 kg N ha-1 and bio-fertilizers. Similar result was also reported by Singh Pramod (2007) [11] shelling percentage were found to be positively

affected by NPK 30:60:30 + Rhizobium + PSB. The yield per hectare was significantly increased by the application of NPK 30:60:30 kg/ha + Rhizobium + PSB.

(Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The results obtained in the present studies are also supported by the El-Shaikh *et al.* (2010) [6] recorded that application of22.5 kg of phosphorus and inoculation with VAM and PSB in pea cultivar in early perfection increase total green pod yield along with the highest number of pods per plant.

It was also revealed from the mean data that among all the treatments, The mean data for significant highest number of seeds per pod (9.25) was noted in treatment T13 (Rhizobium (Liquid)+P.S.B.(Liquid) + 100% RDF). Similar results were also reported by Sharma and Singh (2003) [18] while working at Solan (H.P.) reported that the application of 60 kg P2O5 ha^{-1} gave maximum number of seeds per pod in pea along with 25 kg N and 40 kg K2O ha^{-1}.

It was also revealed from the mean data that among all the treatments, the significant highest pod weight per plant (gm) (84.25) was noted in treatment T13 (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). Similar trend of increased yield parameter *i.e.*, pod weight per plant (gm), pod yield per plot (kg) etc. in pea plant is observed due to inoculation with culture, liquid rhizobium, and PSB Bhattarai *et al*. 2003 [2].

Table 1: Effect of Culture, Liquid and Capsulated Bio Fertilizer on Yield parameters

Tr. No.	Treatment details	Pod length (cm)	Number of pods per plant	Number of seeds per pod	Pod weight per plant (GM)
T1	Control (no fertilizer apply)	5.375	13.95	4.98	54.50
T2	RDF Only (25:50:50) NPK/ha	7.225	17.48	6.83	78.80
T3	Rhizobium (Culture)+PK Supplied Through Fertilizer (0:50:50)	5.85	14.70	5.45	66.50
T4	Rhizobium (Liquid)+PK Supplied Through Fertilizer(0:50:50)	6.05	15.30	5.85	69.50
T5	Rhizobium (Capsule) +PK Supplied Through Fertilizer(0:50:50)	5.625	14.25	5.13	64.17
T6	P.S.B.(Culture) + recommended dose of N&K plus 35% P supply through fertilizer	6.42	15.95	6.20	74.00
T7	P.S.B.(Liquid)+ recommended dose of N&K plus 35% P supply through fertilizer	6.7	16.45	6.35	75.25
T8	P.S.B.(Capsule) + recommended dose of N&K plus 35% P supply through fertilizer	6.195	15.65	6.00	73.00
T9	Rhizobium (Culture)+ P.S.B.(Culture)+ 50% RDF	7.05	16.90	6.55	77.05
T10	Rhizobium (Liquid)+ P.S.B.(Liquid) + 50% RDF	7.125	17.15	6.61	77.60
T11	Rhizobium (Capsulated)+ P.S.B.(Capsulated)+ 50% RDF	6.92	16.65	6.45	76.10
T12	Rhizobium (Culture)+ P.S.B.(Culture)+ 100% RDF	6.885	18.30	7.50	83.00
T13	Rhizobium (Liquid)+ P.S.B.(Liquid) + 100% RDF	7.54	18.60	9.25	84.25
T14	Rhizobium (Capsulated)+ P.S.B.(Capsulated)+100% RDF	7.325	17.70	7.40	82.00
	S.Em (±)	0.395	0.48	0.31	4.16
	CD (P=0.05)	1.175	1.40	0.90	12.12
	CV (%)	10.615	18.62	8.28	9.75
Tr. No.	**Treatment details**	**Days to maturity**	**Pod yield per plot (kg)**	**Total pod Yield (qt ha^{1})**	**Shelling percent**
T1	Control(no fertilizer apply)	83.05	1.30	75.00	42.50
T2	RDF Only (25:50:50) NPK/ha	77.34	3.00	122.00	51.05
T3	Rhizobium (Culture)+PK Supplied Through Fertilizer(0:50:50)	82.09	2.10	105.00	44.00
T4	Rhizobium (Liquid)+PK Supplied Through Fertilizer(0:50:50)	81.39	2.25	107.00	45.23
T5	Rhizobium (Capsule)+PK Supplied Through Fertilizer(0:50:50)	82.55	1.90	102.50	43.25
T6	P.S.B.(Culture)+recommended dose of N&K plus 35% P supply through fertilizer	80.44	2.55	110.00	46.25
T7	P.S.B.(Liquid)+recommended dose of N&K plus 35% P supply through fertilizer	80.00	2.70	112.00	47.13
T8	P.S.B.(Capsule)+ recommended dose of N&K plus 35% P supply through fertilizer	81.08	2.45	108.60	45.95
T9	Rhizobium (Culture)+P.S.B.(Culture)+50% RDF	78.50	2.86	118.50	48.93
T10	Rhizobium (Liquid)+P.S.B.(Liquid)+50% RDF	77.99	2.92	120.50	50.00
T11	Rhizobium (Capsulated)+P.S.B.(Capsulated)+50% RDF	79.09	2.81	116.50	47.60
T12	Rhizobium (Culture)+P.S.B.(Culture)+100% RDF	76.27	3.40	124.50	52.30
T13	Rhizobium (Liquid)+P.S.B.(Liquid)+100% RDF	75.00	3.90	125.51	53.05
T14	Rhizobium (Capsulated)+P.S.B.(Capsulated)+100% RDF	76.75	3.10	123.10	51.50
	S.Em(±)	1.46	0.21	5.96	1.07
	CD(P=0.05)	4.27	0.63	17.33	3.11
	CV(%)	3.21	13.96	9.22	3.90

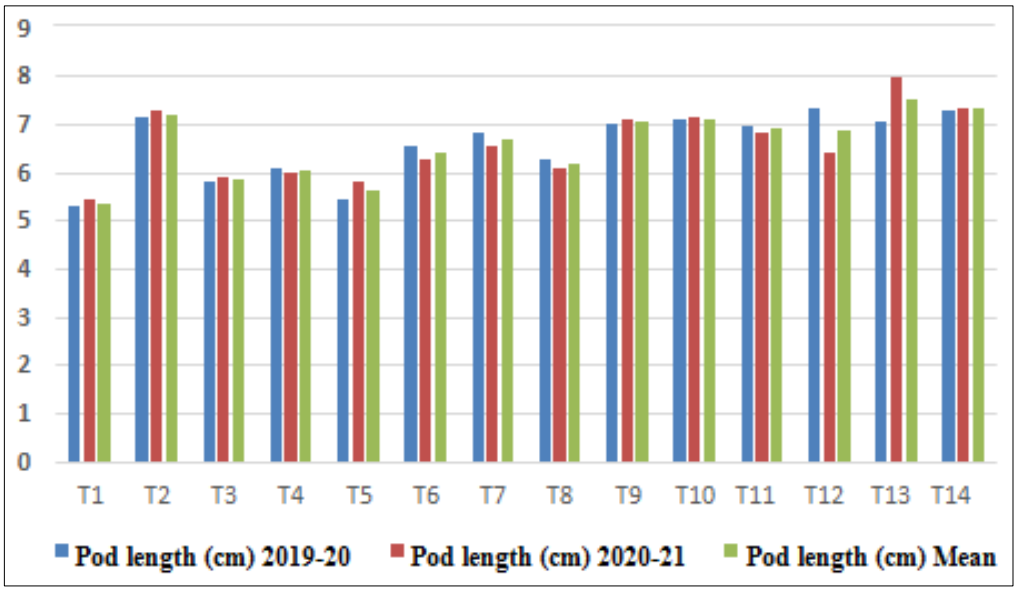

Fig 1: Pod length (cm)

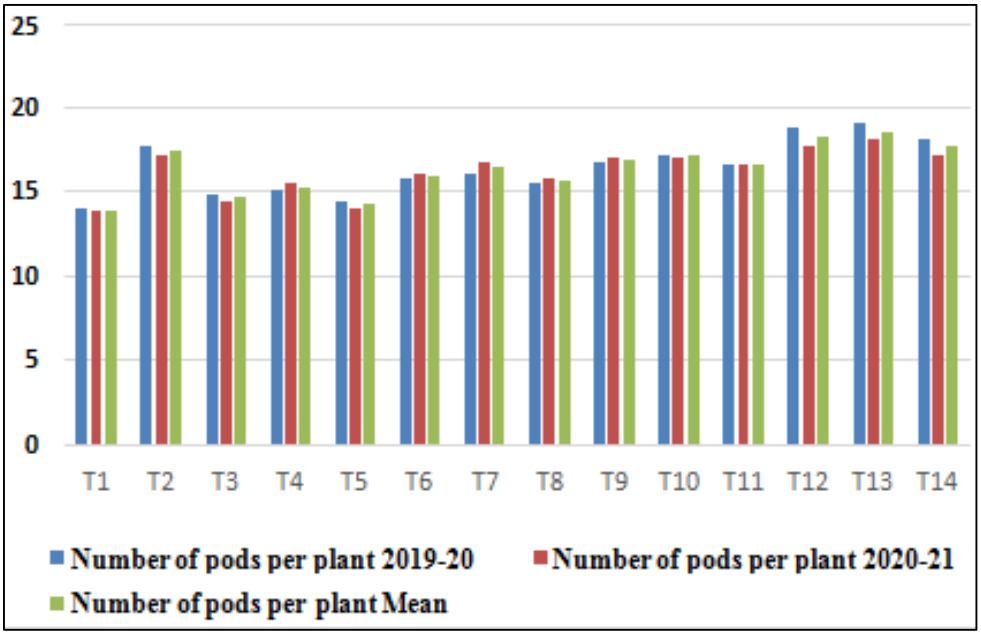

Fig 2: Number of pods per plant

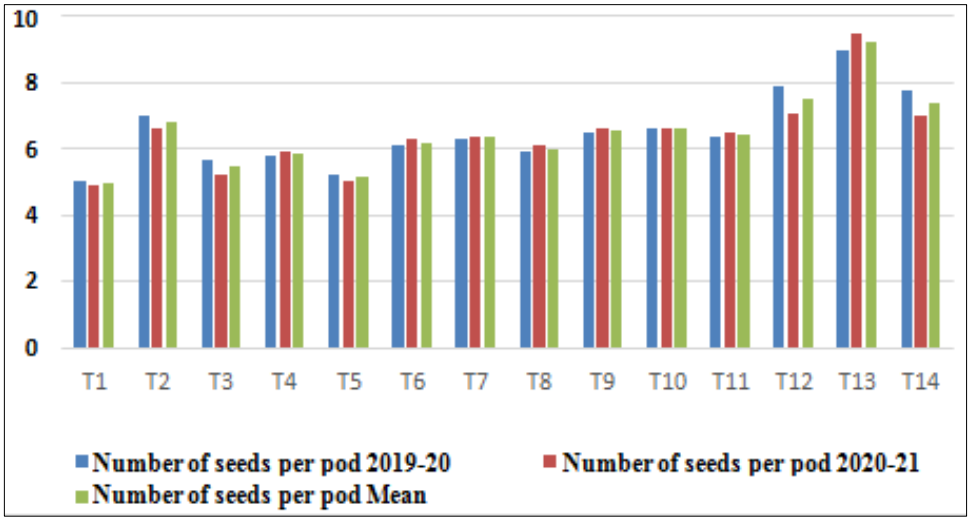

Fig 3: Number of seeds per pod

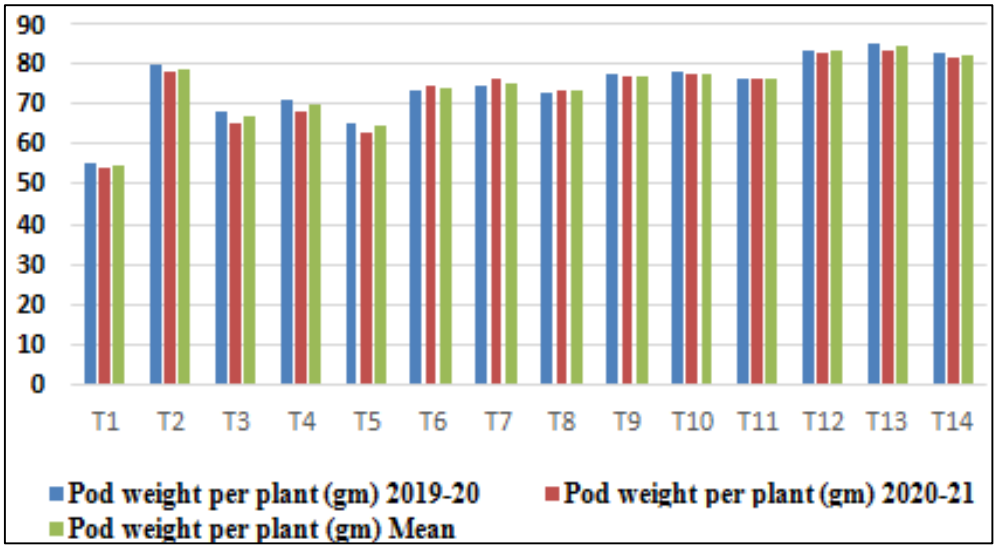

Fig 4: Pod weight per plant (Gm)

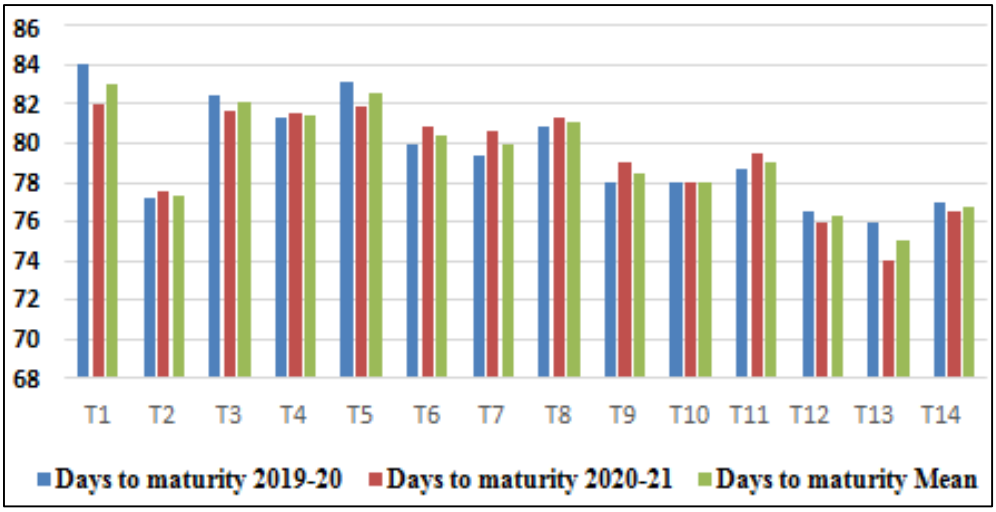

Fig 5: Days to maturity

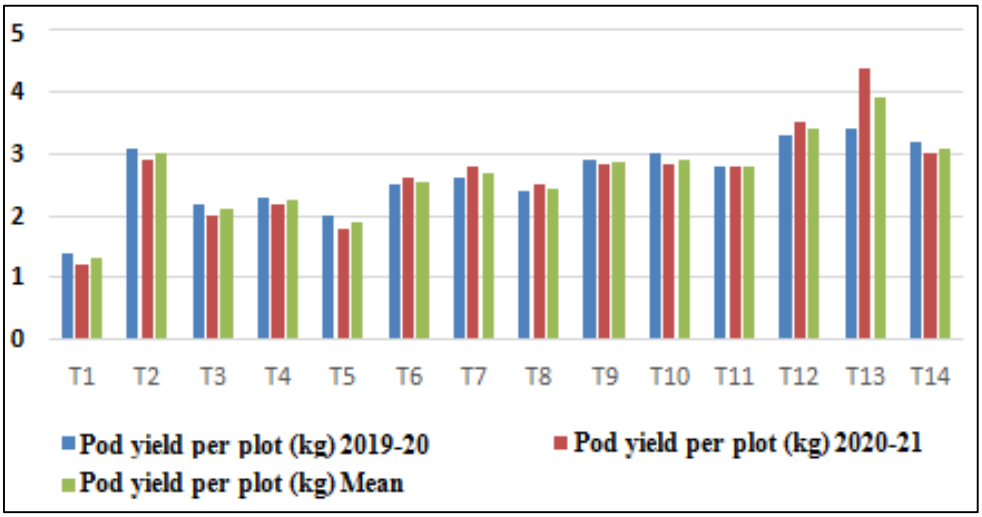

Fig 6: Pod yield per plot (kg)

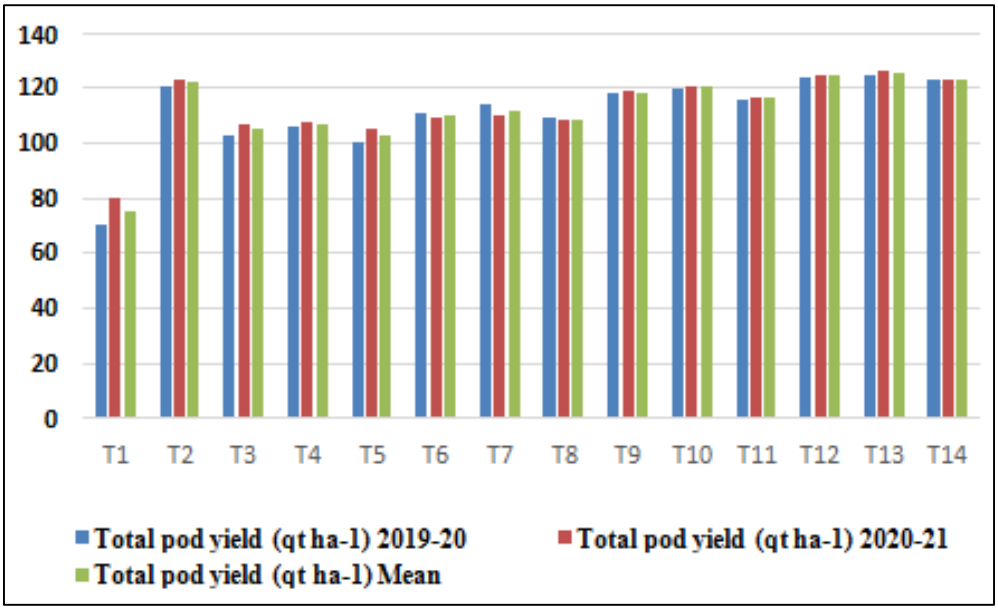

Fig 7: Total pod yield (qt ha-1)

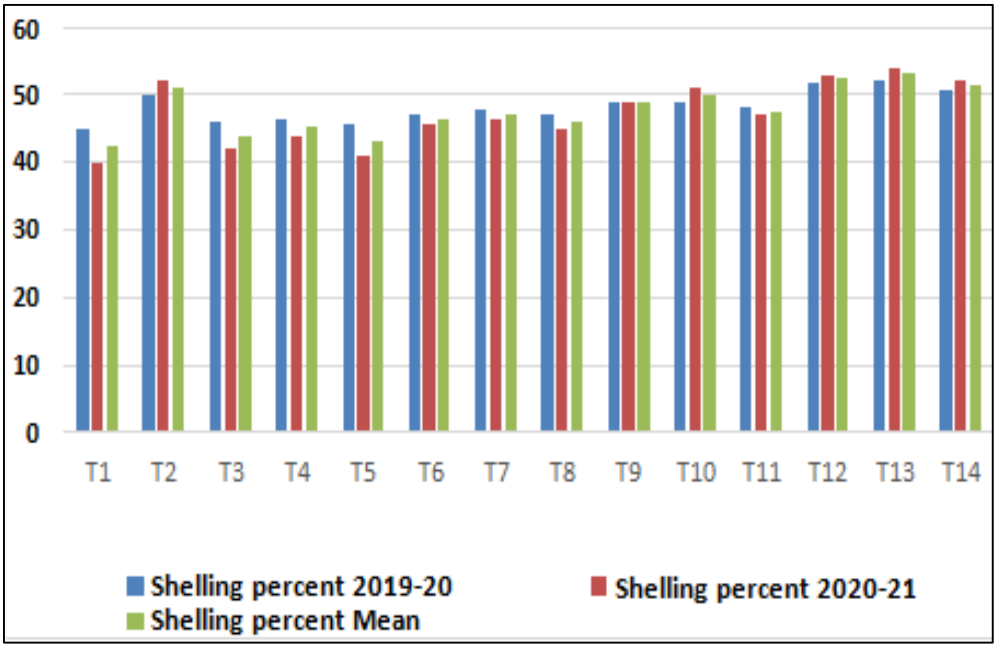

Fig 8: Shelling percent

4. Conclusion

The yield parameters like pod length (cm), number of pods per plant, number of seeds per pod, pod weight per plant (gm), days to maturity, pod yield per plot (kg), total pod yield (qt ha^{-1}), shelling percent and harvest index (%) were significantly superior in the treatment T13(Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF) and similar trend find with treatment T12 (Rhizobium (Culture)+ P.S.B. (Culture) + 100% RDF) and T14 (Rhizobium (Capsulated) + P.S.B.(Capsulated) + 100% RDF).

On the basis of the above finding effect of culture, liquid and capsulated bio fertilizer on growth, yield and quality attributes of vegetable pea from the overall performance and association studies of all parameters stand could be better performance in first in position T13 (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF) and T12 (Rhizobium (Culture) + P.S.B. (Culture) + 100% RDF) stand in second order of preference. However, treatment T14 (Rhizobium (Capsulated) + P.S.B. (Capsulated) + 100% RDF) comes in next in order. Therefore, it may be concluded that treatment T13 (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF) may be prefer for higher growth, quality and yield in vegetable pea.

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