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Studies on the effect of culture, liquid and capsulated bio fertilizer on growth attributes of vegetable pea (*Pisum sativum* L.)

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Abstract
The 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. The growth parameters like days to 50% flowering, plant height (cm), number of branches per plant, number of nodules per plant, fresh weight of nodules per plant (mg), dry weight of nodules per plant (mg), fresh plant weight per plant (g) were significantly superior in the T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF), while remained other treatments namely T_{12} (Rhizobium (Culture) + P.S.B. (Culture) + 100% RDF), T_{14} (Rhizobium (Capsulated) + P.S.B. (Capsulated) + 100% RDF), T_2 (RDF Only (25:50:50) NPK/ha), T_5 (Rhizobium (Capsule) + PK Supplied Through Fertilizer (0:50:50), T_1 Control (no fertilizer apply)) for cut flower production and garden display under Chhattisgarh plain. The mean data revealed that among all the treatments, significant earliness in days to 50% flowering (33.95) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The mean data at harvest, revealed that, significantly highest plant height (55.47) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The mean data at harvest revealed that, significantly highest number of branches per plant (11.12) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The significant highest number of nodules per plant (28.29) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The significant highest fresh weight of nodules per plant (mg) (4450.00) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The significant maximum dry weight of nodules per plant (mg) (825.00) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The significant fresh plant weight per plant (g) (141.00) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF).

Keywords: Growth parameters, rhizobium, fertilizer, nodules, capsulated, RDF, P.S.B, flowering, earliness

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 *viz* protein content, protein quality (having a good amount of essential amino acids such as 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 *et al*. (2011) [10].

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) [15].

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 treatment was done and the treated seed was kept in shade dried for about 30 minutes for the completion of inoculation. The culture was poured on the required seed. *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.

Results and Discussion

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

It was also revealed from the mean data that among all the treatments, significant earliness in days to 50% flowering (33.95) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). Similar results were also observed by Singh Pramod (2007) 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 minimum days (41.33) for 50% flowering. An increase in the above- mentioned characters due to the NPK application is quite reasonable. The higher dose of NPK (25: 50: 50 kg/ha) was more effective than control (no fertilizer apply) meaning thereby that the lower dose was not sufficient.

It was also revealed from the mean data that, at 30 days after sowing among all the treatments, significantly highest plant height (28.32) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). At 60 days after sowing, significantly highest plant height (28.32) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). At harvest, the significantly highest plant height (55.47) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The results in our study, is closely related with the findings of Mishra *et al.* (2010) that plant height increased due to use of 100% RDF and seed inoculation with Rhizobium + PSB, which works as growth attributes and promote cell mitosis, division and elongation of cell. The results obtained in the present study are supported by the works of Kurbah and Thomas (2017) studied the result of integrated nutrient on nutrient uptake and yield of pea plant found that combined use of NPK @ 30:60:40 kg ha^{-1} + *Rhizobium* 200 gm 10 kg^{-1} + FYM 15 t per half seed showed the better result with in terms of plant height (79.33 cm).

The mean data at 30 days after sowing revealed that among all the treatments, significantly highest number of branches per plant (3.75) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). At 60 days after sowing, significantly highest number of branches per plant (5.20 and 5.80) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The mean data at harvest showed the significantly highest number of branches per plant (11.12) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). Similar findings were also reported by Sarkar *et al.* (1991) [11] observed a significant increase in growth of green gram in terms number of branches when seed inoculated with PSB as compared to without inoculation.

The mean data also revealed that among all the treatments, significant highest number of nodules per plant (28.29) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The results obtained in the present study is in closely accordance with the results of Singh *et al.* (2006) observed significantly higher number of nodules and their fresh weight with the treatment Rhizobium + VAM + PSB + 75% RDF of NPK in pea.

The mean data also revealed that among all the treatments, significant highest fresh weight of nodules per plant (mg) (4450.00) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The finding of present study is in accordance with those of Mishra *et al.* (2010) reported that the application of 100 per cent recommended dose of fertilizer (RDF) and seed inoculation with *Rhizobium* + PSB + PGPR improved fresh and dry weight plant-1 and nodules number in pea. Similar results were also obtained by Puniya (2011) [9] reported that application of 40 kg P2O5 ha-1

significantly increased total and effective number as well as fresh and dry weight of root nodules per plant in bean crop.

The mean data also revealed that among all the treatments, significant dry weight of nodules per plant (mg) (825.00) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The findings are also supported by some earlier workers such as Vijayakumar and Lakshminarasimhan (2004) [16] reported that seed inoculation of groundnut with Glomus fasciculatum (VAM) and Rhizobium gave significantly nodules dry weight per plant over control. Similar results were also observed by Singh *et al.* (2009) [7] inoculation of Rhizobium, VAM and N levels in green gram resulted a significant improvement in nodule dry weight, rhizobial counts, root colonization, and spore density over the control.

The mean data also revealed that among all the treatments, significant fresh plant weight per plant (g) (141.00) was noted in treatment T_{13} (Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF). The increase in fresh plant weight per plant (g) might be due to the favorable environment under these treatments which provides congenial conditions for better growth and development of the plant. Similar result was also reported by Singh *et al.* (2002) [12] examined the effect of *Rhizobium* and different levels of phosphorus on the growth parameters and yield and found that both *Rhizobium* inoculation and phosphorus application gave pronounced effect on growth parameters fresh weight and dry weight of per plant.

Table 1: Effect of culture, liquid and capsulated bio fertilizer on morphological and growth parameters

Tr. No.	Treatment details	Days to 50% flowering	Plant height			Number of branches per plant		
			30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1	Control (no fertilizer apply)	42.80	22.57	34.06	47.53	2.18	4.33	7.95
T_2	RDF Only (25:50:50) NPK/ha	36.05	26.53	38.67	52.91	3.15	5.03	9.99
T_3	Rhizobium (Culture) + PK Supplied Through Fertilizer (0:50:50)	41.32	23.85	35.51	48.35	2.35	4.43	8.45
T_4	Rhizobium (Liquid) + PK Supplied Through Fertilizer (0:50:50)	40.45	24.72	36.10	48.78	2.38	4.50	8.66
T_5	Rhizobium (Capsule) + PK Supplied Through Fertilizer (0:50:50)	42.18	23.61	34.80	48.00	2.25	4.38	8.33
T_6	P.S.B. (Culture) + recommended dose of N&K plus 35% P supply through fertilizer	38.04	25.53	37.05	49.84	2.55	4.65	8.88
T_7	P.S.B. (Liquid) + recommended dose of N&K plus 35% P supply through fertilizer	37.26	25.87	37.38	50.35	2.65	4.75	9.12
T_8	P.S.B. (Capsule) + recommended dose of N&K plus 35% P supply through fertilizer	39.09	24.98	36.68	49.51	2.45	4.55	8.76
T_9	Rhizobium (Culture) + P.S.B. (Culture) + 50% RDF	36.39	26.07	38.22	51.75	3.00	4.94	9.63
T_{10}	Rhizobium (Liquid) + P.S.B. (Liquid) + 50% RDF	36.25	26.27	38.42	52.06	3.15	5.00	9.84
T_{11}	Rhizobium (Capsulated) + P.S.B. (Capsulated) + 50% RDF	36.65	25.99	37.95	50.59	2.85	4.87	9.39
T_{12}	Rhizobium (Culture) + P.S.B. (Culture) + 100%RDF	34.75	27.62	39.96	53.85	3.38	5.15	10.33
T_{13}	Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF	33.95	28.32	41.07	55.47	3.75	5.50	11.12
T_{14}	Rhizobium (Capsulated) + P.S.B. (Capsulated) + 100%RDF	35.59	26.92	39.72	53.10	3.35	5.06	10.11
	SEm (±)	1.28	0.82	0.78	1.56	0.30	0.20	0.51
	CD (P=0.05)	3.73	2.39	2.29	4.54	0.88	0.59	1.49
	CV (%)	5.87	5.55	3.64	5.32	18.59	7.38	9.54

Tr. No.	Treatment details	Number of nodules per plant	Fresh weight of nodules per plant (mg)	Dry weight of nodules per plant (mg)	Fresh plant weight per plant (g)
T_1	Control (no fertilizer apply)	9.27	2850.00	550.34	109.00
T_2	RDF Only (25:50:50) NPK/ha	24.32	4170.00	765.00	137.58
T_3	Rhizobium (Culture) + PK Supplied Through Fertilizer (0:50:50)	15.21	3250.00	625.00	121.00
T_4	Rhizobium (Liquid) + PK Supplied Through Fertilizer (0:50:50)	16.68	3375.00	537.67	125.75
T_5	Rhizobium (Capsule) + PK Supplied Through Fertilizer (0:50:50)	14.06	3100.00	610.00	119.00
T_6	P.S.B. (Culture) + recommended dose of N&K plus 35% P supply through fertilizer	18.12	3807.50	675.00	131.75
T_7	P.S.B. (Liquid) + recommended dose of N&K plus 35% P supply through fertilizer	15.06	3875.00	695.00	134.75
T_8	P.S.B. (Capsule) + recommended dose of N&K plus 35% P supply through fertilizer	17.51	3707.84	655.00	128.75
T_9	Rhizobium (Culture) + P.S.B. (Culture) + 50% RDF	21.17	3970.17	727.67	136.83
T_{10}	Rhizobium (Liquid) + P.S.B. (Liquid) + 50% RDF	22.71	4070.17	745.00	137.25
T_{11}	Rhizobium (Capsulated) + P.S.B. (Capsulated) + 50% RDF	20.49	3915.50	715.00	136.50
T_{12}	Rhizobium (Culture) + P.S.B. (Culture) + 100%RDF	26.65	4370.67	795.34	139.60
T_{13}	Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF	28.29	4450.00	825.00	141.00
T_{14}	Rhizobium (Capsulated) + P.S.B. (Capsulated) + 100%RDF	25.69	4270.34	785.00	137.70
	SEm (±)	0.53	150.63	36.80	5.50
	CD (P=0.05)	1.56	437.88	106.98	16.01
	CV (%)	4.77	6.87	9.21	7.27

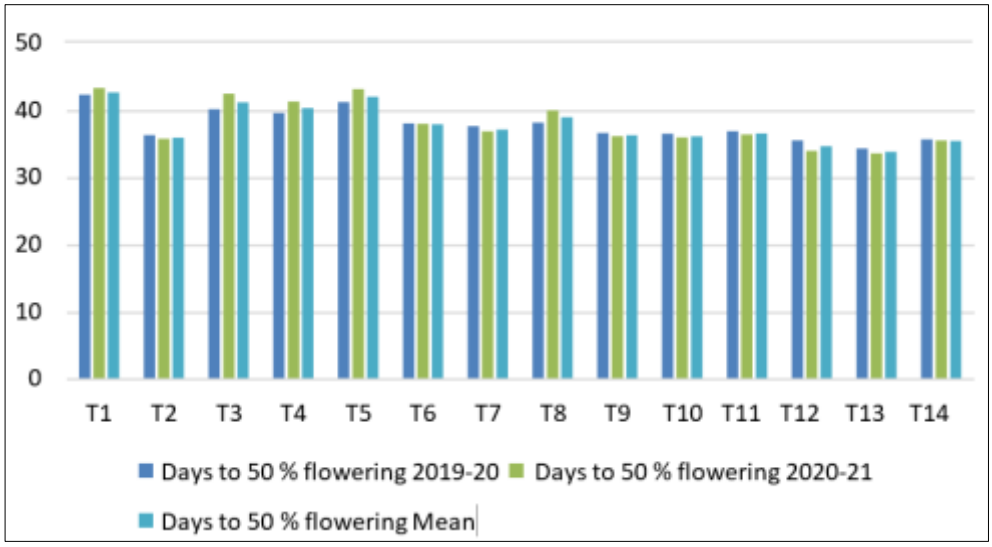

Fig 1: Days to 50% flowering

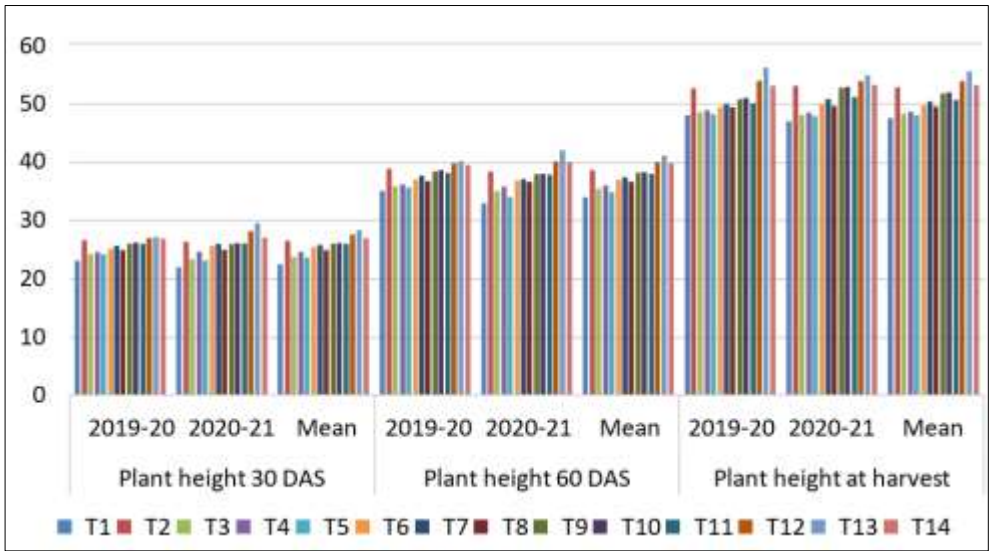

Fig 2: Plant height (cm) at 30, 60 and at harvest

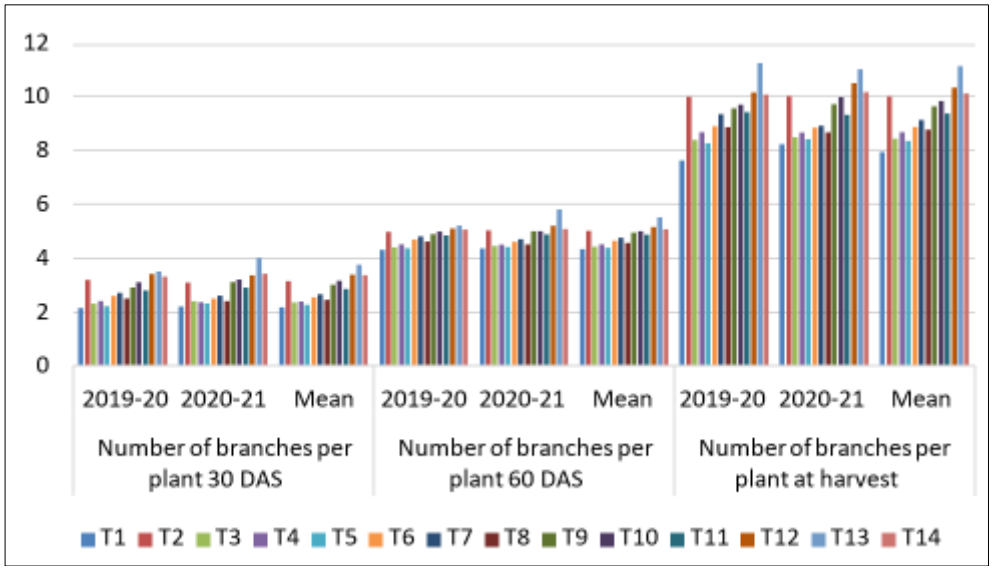

Fig 3: Number of branches per plant

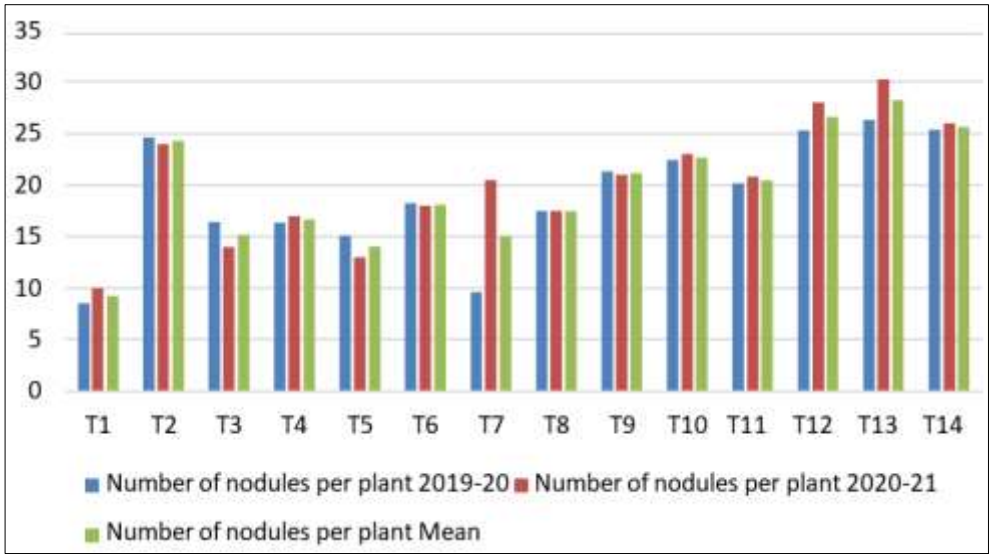

Fig 4: Number of nodules per plant

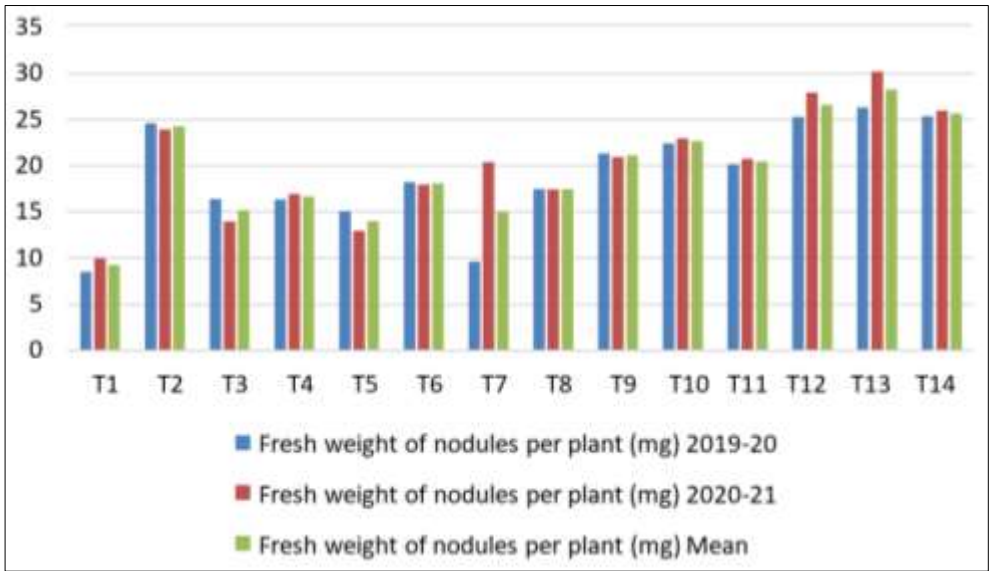

Fig 5: Fresh weight of nodules per plant (mg)

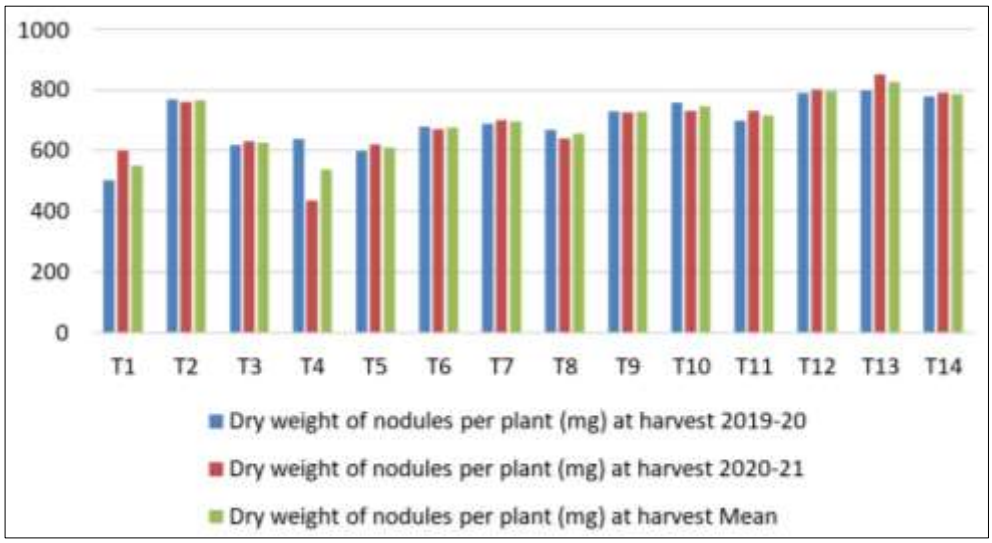

Fig 6: Dry weight of nodules per plant (mg)

Conclusion

The growth parameters like days to 50% flowering, plant height (cm), number of branches per plant, number of nodules per plant, fresh weight of nodules per plant (mg), dry weight of nodules per plant (mg) and fresh plant weight per plant (g) were significantly superior in the treatment T_{13}

(Rhizobium (Liquid) + P.S.B. (Liquid) + 100% RDF) and similar trend find with treatment T_{12} (Rhizobium (Culture) + P.S.B. (Culture) + 100% RDF) and T_{14} (Rhizobium (Capsulated) + P.S.B. (Capsulated) + 100% RDF).

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