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Response of chickpea (*Cicer arietinum* L.) to seed treatment and foliar application of liquid organic under different doses of nutrients

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ABSTRACT

A field experiment was conducted at GBPUA&T, Pantnagar during rabi season of 2020-21 to study the effect of kunapajala, a traditional liquid organic, on plant growth and productivity under different nutrient doses. The experiment comprised of 14 treatments which were laid out in randomized block design with three replications. The treatments included seed invigoration with three concentrations of kunapajalaand four nutrient doses along with two control treatments. All treatments were followed by foliar application of 10% herbal kunapajala except control treatments. The results revealed that 10% kunapajala priming+100% RDN recorded significantly higher field emergence (94.3%), plant population (27.4m^{-2}) and growth attributes like plant height (83.5 cm) and dry matter accumulation (30.3 g) at harvest, number of effective nodule (32.9) and nodule dry weight (118.3 mg). The maximum yield attributes like podsplant^{-1}(84.1) and 100 grains weight (20.7 g) and yield parameters i.e., grain yield (1712.60 kgha^{-1}) and protein yield (358.3kg ha^{-1}) were recorded under 10% kunapajala priming+100% RDN treatment, where as it also recorded the highest economics of cultivation viz., gross returns, net returns and B:C ratio over other treatments. Application of 50% kunapajala priming without fertilizer resulted into lowest plant growth and yield parameters.

Keywords: Chickpea, foliar application, liquid organic, growth promoter, *kunapajala*, seed priming, yield

INTRODUCTION

Chickpea (*Cicer arietinum* L.) from *fabaceae family,* is a cool season pulse crop,beinga rich source of protein (15-22%), carbohydrates (40-60%), fats (4-8%) and minerals such as phosphorus, calcium, magnesium, iron, zinc (Madurapperumage *et al.,* 2021). Globally, chickpea is third most important pulse crop after common bean and field pea. Regardless of its high production and more nutritional value, the productivity of chickpea is low which can be attributed to many biotic and abiotic stress. Poor crop establishment resulted from low quality seed, lack of soil moisture and low temperature stress during germination, is the one of the major constraints which leads to poor crop emergence and subsequentlysparse plant stands. Seed priming is the most promising seed invigoration technique whichquickens the germination process, enhancesstand establishment of crop and promotes seedling vigour. Conventional farming with chemical fertilizers leads to higher yield but its long-term use causes reduction in the soil fertility, deteriorated quality of the produce and environmental pollution. Besides, excessive use of chemical fertilizers without organics leads to several issues such as soil degradation, soil compaction, nitrogen leaching, reduction in soil organic matter as well as loss of soil organic carbon. Hence, there is an urgent need to adapt some alternative approaches for the replenishment of soil fertility. One such alternative approach is traditional *vrikshayurveda* practices like use of traditional liquid organic concoction i.e.,*kunapajala*, *panchyagavya* which have been traditionally used to improve soil health and crop productivity. *Kunapajala* is liquid fermented organic manure made from animal waste containing animal flesh, dung, urine, bones, marrow and skins (non-herbal *kunapajala*) or the plant products (herbal *kunapajala*). *Kunapajala* is mainly used as foliar nutrition, soil drenching (Kavya *et al.*, 2020) and priming medium for many agricultural and horticultural crops because of having biostimulant, nutrition and antimicrobial properties.This liquid organic concoction contains macro and micro nutrients (Ankad *et al.*, 2017), vitamins, growth regulators like IAA and GA_3, essential amino acidsand beneficial

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microbes like *Rhizobium, Azotobacter, Azospirillum*, phosphorus solubilizing bacteriaand *Pseudomonas* (Ali *et al.*, 2012). Application of liquid organic along with chemical fertilizer significantly enhances the plant growth due to improved mobilization and rapid availability of essential plant nutrients. Higher microbial load and growth hormones in liquid organic enhances soil biomass and thus sustaining the availability and uptake of applied nutrients and native nutrients in soil which ultimately promotes growth and productivity of crops (Priyadharshini and Madhanakumari, 2021). So, *kunapajala* is a promising and eco-friendly biostimulant for sustainable crop production and maintaining safe agro-ecosystem (Kavya *et al.*, 2020). Information regarding the use of herbal *kunapajala* for seed treatment and foliar nutrient is meagre. Hence, attempts have been made to study the effect of herbal *kunapajala*, a traditional liquid organic on growth and productivity of chickpea under different doses of nutrients.

MATERIALS AND METHODS

The field experiment was conducted at NEBCRC of G.B. Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand) during *rabi* season of 2020-21. The research area is situated at 29˚ N latitude and 79.50˚ E longitude and an altitude of 243.83 m above MSL.The chickpea variety Pant gram-5 was sown on 21st November, 2020 with a seed rate of 70 kg ha^{-1} and spacing of 30 cm × 10 cm and was harvested on 8th April, 2021. During the crop season, the average weekly maximum temperature varied from 16ºC to 34.4ºC while the minimum temperature fluctuated from 4.1ºC to 14.6ºC. The total amount of rainfall received during crop growing period was 25.70 mm.The initial soil status of the experimental area was clay loam in texture with high organic C (8.1 g kg^{-1}), low in available N (148 kg ha^{-1}) and medium in available P (23kg ha^{-1}) and available K (178 kg ha^{-1}) and soil pH of 6.7. The field experiment was laid out in simple randomized block design with three replications and the net plot size of 1.5 m × 4.8 m. The study comprised of 14 treatments *viz*. T_1: No priming + 100% RDN, T_2: Hydropriming + 100% RDN, T_3: 10% *kunapajala*priming + 100% RDN, T_4: 10% *kunapajala* priming + 75% RDN, T_5: 10% *kunapajala*priming + 50% RDN, T_6: 10% *kunapajala* priming + no Fertilizer, T_7: 25% *kunapajala*priming + 100% RDN, T_8: 25% *kunapajala*priming + 75% RDN, T_9: 25% *kunapajala* priming + 50% RDN, T_{10}: 25% *kunapajala* priming + no fertilizer, T_{11}: 50% *kunapajala* priming + 100% RDN, T_{12}: 50% *kunapajala* priming + 75% RDN, T_{13}: 50% *kunapajala* priming + 50% RDN, T_{14}: 50% *kunapajala*priming + no fertilizer. All treatments were followed by foliar application of 10% herbal *kunapajala* at 30, 60, 80, 90, 100, 110 and 120 DAS except T_1 and T_2. The recommended dose of nutrient (RDN) was 20kg N + 50 kg P_2O_5+ 25 kg K_2O ha^{-1}. The seeds were treated with different concentration of herbal *kunapajalaviz*, 10%, 25% and 50% along with hydropriming (tap water) for 8 hours in the ratio of 1:2 (seed: priming media) (w/v) followed by shade drying to reach initial moisture content. The field emergence count was recorded daily up to 15 DAS from 2m row length in third row and expressed as percentage as per the formula (Scott *et al.*, 1984). Total plant population was recorded at harvest from net plot area and expressed in m^{-2}. Plant growth parameters like plant height (cm) and dry matter accumulation (gplant^{-1}) at harvest, number of effective nodules plant^{-1} and dry weight of nodules plant^{-1} (mgplant^{-1}) at flowering stage and yield attributes like number of pods plant^{-1}, number of grains pod^{-1} and 100 grain weight (g) were determined. The grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index were recorded from net plot area. The nitrogen content of the grain was determined by micro Kjeldhal's method (Jackson, 1973). Then, the protein content (%) of grains was worked out by multiplying the nitrogen content with 6.25. Simultaneously the protein yield (kg ha^{-1}) was calculated by multiplying the grain yield with protein content. Economics like cost of cultivation, gross returns, net returnsand B:C ratio were also calculated under different treatments during the course of experiment.Analysis of the data gathered from different observations was doneas pertheanalysis of Variance (ANOVA) technique for simple randomized block design using standard procedure given by Gomez and Gomez (1984).The critical difference was calculated at 5% level of significance.

RESULTS AND DISCUSSION

Field emergence and plant stand

The field emergence % and plant stand at harvest were significantly influenced by herbal *kunapajala* treatments and different nutrient doses (Table 1). The highest field emergence % was jointly recorded from priming with 10% *kunapajala* + 100% RDN (94.3%) and priming was 25% *kunapajala + 75% RDN* (90.3%) among all the treatments whereas significantly superior plant population was observed from priming with 10% *kunapajala* + 100% RDN (27.4 m^2), priming with 25% *kunapajala* + 100% RDN (26.2 m^{-2}) and priming with 10% *kunapajala* + 75% RDN (26.0 m^{-2}) over all the treatments. However, application of 50% *kunapajala* priming+ no fertilizer resulted into the lowest field emergence % and plant stand (43.3% and 10.1 m^{-2}, respectively). The enhancement of seedling emergence of primed seeds in comparison to untreated seeds was due to faster water uptake and greater activity of α-amylase which increased the breakdown of starch and supply the energy for germination. The presence of amino acids, vitamins and growth regulators like IAA and GA_3 in herbal *kunapajala* formulations may trigger the α-amylase activity in *kunapajala* primed seeds and consequently resulted into rapid seedling emergence and better establishment. Significant improvement in field emergence and plant stand of primed seeds of chickpea over control also have been reported by Farooq *et al.* (2019) and Ankad *et al.* (2017). However, field emergence % and plant stand were reduced with increasing concentration of *kunapajala* in priming media which may be due to supra optimal dose of organic product which is normally specific to crops and reduced water uptake as well as slow breakdown of starch.

Table 1: Field emergence, plant population and growth parameters of chickpea as affected by different treatments

Treatment	Field emergence (%)	Plant population m^{-2} at harvest	Plant height at harvest (cm)	Dry matter at harvest (g $plant^{-1}$)	Effective nodules $plant^{-1}$	Nodule dry weight (mg $plant^{-1}$)
T_1	75.7	21.8	70.4	24.4	23.5	52.2
T_2	81.3	22.8	77.0	27.6	25.6	97.2
T_3	94.3	27.4	83.5	30.3	32.9	118.3
T_4	87.7	26.1	75.5	26.5	29.0	113.0
T_5	86.0	23.8	75.0	24.1	24.7	83.0
T_6	74.0	20.4	60.8	21.6	18.3	32.2
T_7	90.3	26.3	76.1	29.0	31.2	113.8
T_8	80.7	23.5	74.4	25.2	30.9	101.8
T_9	81.7	23.2	68.3	21.6	22.4	68.0
T_{10}	66.3	17.9	59.4	21.1	15.3	29.8
T_{11}	55.0	14.2	69.5	23.5	21.6	47.8
T_{12}	51.7	12.7	60.7	20.9	20.2	30.8
T_{13}	49.3	13.2	58.4	20.1	18.4	29.3
T_{14}	43.3	10.1	55.7	18.4	10.5	20.8
SEm±	7.55	2.63	2.35	1.30	1.08	4.67
CD(p=0.05)	22.06	7.68	6.86	3.79	3.15	13.65

T_1-No priming + 100% RDN, T_2-Hydropriming + 100% RDN, T_3-10% *kunapajala* priming + 100% RDN, T_4-10% *kunapajala* priming + 75% RDN, T_5-10% *kunapajala* priming + 50% RDN, T_6-10% *kunapajala* priming + No Fertilizer, T_7-25% *kunapajala* priming + 100% RDN, T_8- 25% *kunapajala* priming + 75% RDN, T_9-25% *kunapajala* priming + 50% RDN, T_{10}-25% *kunapajala* priming + No fertilizer, T_{11}- 50% *kunapajala* priming + 100% RDN, T_{12}-50% *kunapajala* priming + 75% RDN, T_{13}-50% *kunapajala* priming + 50% RDN, T_{14}-50% *kunapajala* priming + No fertilizer; KJ: *Kunapajala*; RDN: Recommended dose of nutrient; All treatments are followed by foliar spray of 10% KJ at 30, 60, 80, 90, 100, 110 and 120 DAS except T_1 and T_2.

Growth parameters

Data (Table 1) revealed that different herbal *kunapajala* treatments and nutrient doses had significant impact on both plant height and dry matter accumulation at harvest. Significantly taller plant was noticed from priming with 10% *kunapajala* + 100% RDN treatment (83.5 cm) which was at par with hydropriming + 100% RDN treatment (77.0 cm). Significant increase in plant dry matter was observed from priming with 10% *kunapajala* + 100% RDN treatment (30.3 g) among all the treatments, but remained at par with priming with 25% *kunapajala* + 100% RDN (29.0 g) and hydropriming + 100% RDN treatment (27.6 g). However, the lowest plant height and dry matter accumulation were recorded from 50% *kunapajala* priming+ no fertilizer (55.7 cm and 18.4 g, respectively).The enhancement in plant growth might be attributed to rapid assimilation of essential nutrients by microorganisms at required time as well as faster availability of nutrients to plants resulted from breakdown of complex molecules like fats, proteins and carbohydrates into simple forms. Presence of macro and micro nutrients, beneficial microorganisms (Ali*et al.*, 2019), many vitamins, hormones, enzymes and growth promoters like IAA and GA_3supplied through foliar application of herbal *kunapajala* (Kavya *et al.*, 2020) also improved the plant growth. Kavya *et al.*(2020) and Sarkar *et al.*(2013) reported the Improvement in plant height and biomass production due to application of kunapajala was previously reported.Nitrogen is a significant component of protoplasm which helps in photosynthesis. It enhanced the metabolic rate, cell division and cell elongation which allowed faster plant growth. Similarly, phosphorous helps in N metabolism, root elongation, leaf expansion and biosynthesis of proteins, phospholipids and nucleic acidswhile potassium improves photosynthetic area and photosynthetic activity and thus produced more dry matter. Therefore, application of nutrients in adequate amount improved the biochemical and physiological function of plant which ultimately enhanced the plant height and dry matter production while lesser as well as no nutrient application could not fulfil the plant requirements and they remained short. These results corroborate the findings made by Kurdali*et al.* (2002). However, the significant decrease in plant with increasing *kunapajala* concentration might be due to poor crop establishment.

Perusal of data (Table 1) indicated that significantly higher number of effective nodules was recorded from application of 10% *kunapajala*priming + 100% RDN (32.9) which remained statistically at par with 25% *kunapajala* priming + 100% RDN (31.2) and 25% *kunapajala* priming + 75% RDN (30.9). Application of 10% *kunapajala* priming + 100% RDN being at par with 25% *kunapajala* priming + 100% RDN (113.8 mg) and 10% *kunapajala* priming + 75% RDN (113.0 mg) exhibited highest dry weight of nodules (113.8 mg). However, the lowest number of effective nodules and dry weight of nodules were observed from 50% *kunapajala* priming+ no fertilizer (10.5 and 20.8 mg, respectively). Timely cell division and expansion due to activity of hydrolytic enzymes of the hydrated seeds over non-primed seeds, early seedling establishment and better rooting and root biomass production might have attributed to more rhizobial population and their symbiosis with the legume plant(Lhungdim *et al.*, 2014). Besides faster supply of readily available nutrients to plantsas well as presence of growth promoting hormones like IAA, GA_3 through foliar application of *kunapajala*under adequate nutrient dose stimulated the root development of plant which might have enhanced the nodulation in plant. Enhancement in nodulation due to seed priming over unprimed seeds also has been reported by Lhungdim *et al.* (2014) in lentil. Phosphorus has specific role in nodule initiation, nodule growth and function besides its important role in root growth of host plant which directly influences the nodulation as well as nodule dry weight. Those results are in close authentication with findings of Gan *et al.*(2008) and Singh *et al.* (2021).However, comparatively reduced nodulation and nodule dry weight under 50% *kunapajala* priming and lesser nutrient doses might be resulted from poor seedling vigour, poor crop establishment and poor root development.

Yield attributes and yield

The number of podsplant^{-1} and 100 grains weight were significantly differed due to herbal *kunapajala* treatments and nutrient doses while it failed to bring significant variation in number of grainspod^{-1} of chickpea (Table 2). Significantly superior number of podsplant^{-1}wasnoticed with 10% *kunapajala* priming + 100% RDN (84.1) which remained at par with 25% *kunapajala* priming + 100% RDN (77.3) whereas 10% *kunapajala* priming + 100% RDN being at par with 10% *kunapajala* priming + 75% RDN (20.52 g), 25% *kunapajala* priming + 100% RDN (20.52 g) and 25% *kunapajala* priming + 75% RDN (20.27 g), significantly produced higher 100 grains weight (20.71 g) among all treatments. Faster seedling emergence from primed seeds might have resulted into improved seedling vigour and better utilization of resources, resulting into enhancement of yield parameters of crop. Enhancement of yield attributes due to priming has already been reportedby Zarei *et al.* (2011) in chickpea, Ghassemi-Golezani *et al.* (2010) in pinto bean.Adequate availability of N, P and K from higher nutrient dose along with foliar application of herbal *kunapajala*having growth promoter and systemic regulator properties stimulated the biological efficiency of crop. Moreover, high dry matter accumulation per plant resulted into higher translocation of photosynthates from vegetative to reproductive parts which resulted into greater number of pods/plant and 100 grains weight. These results are in close confirmation of Ali *et al.* (2012).

Table 2: Yield attributes and yield of chickpea as affected by herbal kunapajala treatments and nutrient doses

Treatment	Pods plant^{-1}	Grains plant^{-1}	100 grains weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	Protein content (%)	Protein yield (kg ha^{-1})
T_1	62.5	1.3	18.55	1340.74	2214.81	37.7	20.8	279.2
T_2	68.1	1.5	19.24	1603.71	2547.22	38.7	20.8	333.8
T_3	84.1	1.7	20.71	1712.6	2588.43	39.8	20.9	358.3
T_4	71.1	1.7	20.52	1593.34	2423.15	39.7	20.9	333.5
T_5	64.9	1.4	19.38	1431.94	2332.87	38.7	20.9	299.5
T_6	63.5	1.3	18.73	1207.98	2241.2	36.6	20.9	251.3
T_7	77.3	1.5	20.52	1654.16	2416.66	40.7	20.9	345.9
T_8	69.1	1.5	20.27	1505.55	2483.38	37.7	20.9	314.4
T_9	63.2	1.5	18.91	1452.78	2108.33	40.9	20.9	304.3
T_{10}	60.5	1.4	18.69	1042.13	2022.68	34.6	20.9	216.3
T_{11}	55.1	1.4	19.03	1234.57	2383.95	34.2	20.7	256.0
T_{12}	48.2	1.3	18.99	1129.63	1902.78	37.4	20.8	235.6
T_{13}	42.5	1.4	18.84	1095.84	2000.46	35.6	20.8	229.4
T_{14}	40.1	1.3	18.65	895.66	1828.7	33.1	20.8	185.4
SEm±	2.80	0.11	0.43	52.26	197.73	2.70	0.94	19.77
CD (p=0.05)	8.18	NS	1.25	152.76	NS	NS	NS	57.79

Different *kunapajala* treatments along with nutrient doses significantly affected the grain yield and protein yield, though the stover yield, harvest index and protein content of seeds varied non-significantly (Table 2). Application of 10% *kunapajala* priming + 100% RDN (1712.60 kgha^{-1}), being at par with 25% *kunapajala* priming + 100% RDN (1654.16 kg ha^{-1}), hydropriming + 100% RDN (1603.71 kg ha^{-1}) and 10% *kunapajala* priming + 75% RDN (1593.34 kg ha^{-1}) recorded significantly superior grain yield among all the treatments. The highest protein yield (279.1 kg ha^{-1}) was observed with 10% *kunapajala* priming + 100% RDN. However, application of 50% *kunapajala* priming + no fertilizer resulted into the lowest grain and protein yield (895.7 and 185.4kg ha^{-1}), respectively. Significant increase in grain yield may be attributed to significant enhancement in number of pod/splant^{-1} and hundredgrains weight. Better crop establishment and adequate supply of N, P and K from higher nutrient doses along with the presence of organic carbon, essential macro and micro nutrients, beneficial microbes, growth hormones, vitamins and amino acids in liquid concoctionstimulated the photosynthate production as well as its distribution in sink and thus increasing the crop yield over no priming along with 100% nutrient application. These findings are also confirmed by Kulkarni *et al.* (2015), Kavya *et al.* (2020) and Ali *et al.* (2012). Significantly higher yield of chickpea with priming methods over no priming also have been reported by Farooq *et al.* (2019). The improvement in protein yield is mainly attributed to grain yield of chickpea as protein content of grains remained non- significant by *kunapajala* treatments and nutrient doses. However, poor crop establishment and hampered production and assimilation of photosynthates resulted from the inhibitory effect of high concentration of *kunapajala* in priming media combined with lower nutrient doses reduced the yield parameters of crop.

Economics

Economics of cultivation *viz*. gross returns, net returns and B:C ratio were differed significantly due to herbal *kunapajala* treatments and nutrient doses (Table 3). Application of 10% *kunapajala* priming + 100% RDN (Rs.137008ha^{-1} and Rs.92856ha^{-1}, respectively) was being at par with 25% *kunapajala* priming + 100% RDN (Rs.132334ha^{-1} and Rs.88075ha^{-1}, respectively). Priming with 10% *kunapajala* + 100% RDN treatment (2.10) had significantly higher B:C ratio among all the treatments, but remained at par with 25% *kunapajala* priming + 100% RDN (1.99) and 10% *kunapajala* priming + 75% RDN (1.94). However, application of 50% *kunapajala* priming + no fertilizer resulted in the lowest gross returns, net returns and B:C ratio (Rs. 71653ha^{-1}, Rs. 30490ha^{-1} and 0.74, respectively).Difference in gross returns under different treatments were mainly due to variation in grain yield. Since priming with 10% *kunapajala*under 100% RDN followed by foliar application of 10% herbal *kunapajala*gave significantly higher gross returns, hence it resulted into higher net returns compared to other treatments. Comparatively higher net returns to total cost of cultivation from *kunapajala* treatments and nutrient doses was the reason for higher benefit to cost ratio. Similar economic benefits from applications of liquid organics and higher nutrient doses also have been reported by Kulkarni *et al.* (2015).

Table 3: Economics of chickpea as affected by herbal kunapajala treatments and nutrient doses

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1	46513	107259	60746	1.31
T_2	46513	128297	81784	1.76
T_3	44152	137008	92856	2.10
T_4	43334	127466	84132	1.94
T_5	42516	114556	72040	1.70
T_6	40879	96638	55759	1.36
T_7	44259	132334	88075	1.99
T_8	43440	120445	77005	1.77
T_9	42622	116222	73600	1.73
T_{10}	40985	83370	42385	1.03
T_{11}	44437	98765	54328	1.22
T_{12}	43618	90370	46752	1.07
T_{13}	42800	87666	44866	1.05
T_{14}	41163	71653	30490	0.74
SEm±	-	4181	4181	0.10
CD (p=0.05)	-	12221	12221	0.29

Based on the findings, it may be inferred that seed invigoration with 10% herbal *kunapajala* along with foliar application of 10% herbal *kunapajala* under balanced nutrient application was the most effective method over no priming+100% nutrient to improve crop establishment, productivity and profitability of chickpea. Seed priming with higher level of herbal *kunapajala* was not found suitable for establishment and growth of chickpea. However, integrated application of full dose of inorganic nutrient and liquid organic was most productive and economical option over lower doses of nutrients. Further studies are essentially needed to explicate the detailed interaction mechanism of plant growth stimulation by the traditional liquid organic.

REFERENCES

Ali, N., Chakraborty, S. and Paramanik, A. (2012) Enhancing the shelf life of kunapajala and shasyagavya and theireffects on crop yield. *International Journal of Bio-resource and Stress Management* **3**(3): 289-294.

Ankad, G. M., Hiremath, J., Patil, R. T., Pramod, H. J. and Hegde, H. V. (2017) Nutrient analysis of kunapajala and panchagavya and their evaluation on germination of ashwagandha and kalamegha seeds: A comparative study. *Journal of Ayurveda* *and integrative medicine***9**(1): 13-19.

Farooq, M., Hussain, M., Imran, M., Ahmad, I., Atif, M. and Alghamdi, S. S. (2019) Improving the productivity and profitability of late sown chickpea by seed priming. *International Journal of Plant Production***13**(2): 129-139.

Gan, Y., Jayakumar, P., Symons, S. and McDonald, C.L. (2008)Synergic effect of N and moisture on biochemicalproperty of nodules and seed yield in chickpea. *Australian Journal of Crop Science***1**(1): 11-22.

Ghassemi-Golezani, K., Chadordooz-Jeddi, A., Nasrollahzadeh, S. and Moghaddam, M. (2010) Effects of hydro-priming duration on seedling vigour and grain yield of pinto bean (*Phaseolus vulgaris* L.) cultivars. *NotulaeBotanicae Horti Agrobotanici Cluj* **38**(1): 109-113.

Gomez, K.A. and Gomez, A.A. (1984)Statistical procedure for agricultural research, 2ndEdn. John Wiley & Sons, New York, 241–271.

Jackson, M.L. (1973) Soil chemical analysis. Prentice Hall pvt. Ltd., New Delhi.

Kavya, S.R. andUshakumari, K. (2020) Effect of organic liquid manure of kunapajala on growth and yield of bhindi [*Abelmoschus esculentus* (L.) Moench.]. *Agricultural Science Digest***40**(3): 270-274.

Kulkarni, S., Upperi, S.N. and Jadhav, R.L. (2016) Greengram productivity enhancement through foliar spray ofnutrients. *Legume Research***39**(5): 814-816.

Kurdali, F., Al-Ain, F. and Al-Shamma, M. (2002) Nodulation, dry matter production, and N_2 fixation by fababean and chickpea as affected by soil moisture and potassium fertilizer. *Journal of Plant Nutrition* **25**(2): 355-368.

Lhungdim, J., Chongtham, S.K., Koireng, R.J. and Neupane, M.P. (2014) Seed invigoration and yield of lentil (*Lens culinaris*Medikus) through seed priming under different seeding rates. *Environment and Ecology***32**: 527-531.

Madurapperumage, A., Tang, L., Thavarajah, P., Bridges, W., Shipe, E., Vandemark, G. andThavarajah, D. (2021) Chickpea (*Cicer arietinum* L.) as a source of essential fatty acids - a biofortification approach. *Frontiers in plant science***12**: 734980.

Priyadharshini, V.M. andMadhanakumari, P. (2021) Effect of bio stimulants on the yield of bush bean (*Lablab purpureus* var. typicus). *Annals of Plant and Soil Research* **23**(1): 66-70.

Sarkar, S., Kundu, S.S. and Ghorai, D. (2014)Validation of ancient liquid organics-Panchagavya and kunapajala as plant growth promoters.*Indian Journal of Traditional Knowledge***13**(2): 398-403.

Scott, S., Jones, R. and Williams, W. (1984) Review of data analysis methods for seed germination. *Crop Science***24**: 1192-1199.

Singh, G., Lal, M. and Kumar, P. (2021) Influence of plant densities and fertility levels on growth and yield of chickpea (*Cicerarietinum*L.) genotypes. *Annals of Plant and Soil Research***23**(1): 112-115.

Zarei, I., Mohammadi, G., Sohrabi, Y., Kahrizi, D., Khah, E.M. andYari, K. (2011) Effect of different hydropriming times on the quantitative and qualitative characteristics of chickpea (*Cicer arietinum* L.). *African Journal of Biotechnology* **10** (66): 14844-14850.