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Impact of soil oxygenation on seed quality of chickpea (*Cicer arietinum* Linn. cv. 'vijay') under organic farming condition

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Pot culture experimentation was carried out on chickpea (*Cicer arietinum* Linn. cv. 'vijay') at P.G. Research Center, Department of Botany, Tuljaram Chaturchand College, Baramati, using oxygenated peptone (2g/pot) as soil aerator. This treatment enhanced root system with increased length and biomass of root exhibiting increased absorptive area. This led to increase in total nitrogen, total phosphorous and total potash in root, stem and leaf. The treatment also increased accumulation of manganese, calcium and magnesium in root, stem and leaf, while zinc content was found to be decreased in root as well as in stem and it was stable in leaf. Interestingly, iron content was enhanced in leaf and root while it showed decrease in stem. The copper content was increased in root, stable in stem and decreased in leaf. The treatment resulted in early flowering and early maturity. There was increase in pods/plant as well as fresh wt and dry wt of 100 pods. The same is seen in seeds. The biochemical constituents of seed like total solids, ash, total acids, moisture content and crude fibre showed significant increase. The treatment also had an upper hand in soluble proteins, total carbohydrates and ascorbic acid under experimental condition. This indicated better nutritional quality of experimental seeds. The activity of enzymes like catalase, peroxidase and polyphenol oxidase was at higher level under the treatment condition. It is concluded that treatment of oxygenated peptone is useful for the qualitative and quantitative enhancement in chickpea under organic farming condition.

Keywords: Biochemical constituents, Chickpea, *Cicer arietinum,* Enzyme activity, Minerals, Organic farming, Oxygenated peptone, Yield.

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Introduction

Legumes, especially pulses, provide protein rich food for man and livestock. Chickpea (*Cicer arietinum* Linn.) is a cool season, food legume crop. It is grown usually as a rain fed, cool-weather crop as well as a dry climate crop in semi-arid tropics. It is a good source of cholesterol-lowering fibre. In addition, high fibre content in chickpea prevents blood sugar levels from rising too rapidly after a meal, making these beans an especially good choice for individuals with diabetes[1]. Chickpea provides virtually fat-free high quality protein. It is a good source of thymine and lysine. India is the topmost chickpea producing country in the world (FAO, 2005). Unfortunately, Indian agriculture is facing a serious problem of soil degradation, water pollution due to phosphates and nitrates, pest resurgence, pesticide residues entering food chain, etc. All these factors led to serious hazards to health of soil, water and human being along with diminishing soil fertility and crop productivity. Singh *et al*[2] remarked that the present production system has endangered our health and environment security due to excessive use of chemical fertilizers and pesticides. Therefore, need for sustainable agriculture is increasingly felt. Organic farming is a sound and viable option for this problem. Organically grown food is nutritious, tastier and leads to better health[3]. According to Dahama[4] organically grown food products (Green food) catch about 15-25% higher market price than chemical food items. However organic farming lags by 5-15% in yield than the conventional chemical farming. Kitchen *et al*[5] also found significantly lower grain yield in organic farming system. In order to balance this situation, it was felt to have a viable program not only to check soil degradation, water pollution, high residues of hazardous chemicals in food but also to sustain the food production and to improve the soil health without affecting the crop productivity. Hence in the present investigation, an innovative technique of

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soil application of oxygenated peptone is employed which fulfils the criteria of organic farming and yet enhances the yield[6,7].

Oxygenated peptone fulfills the oxygen demand of roots and allows them to grow to full extent in normal as well as oxygen deficient soil. It offers three basic changes in vicinity of seed/root, leading to number of physical, chemical and biological interactions of plant with soil and soil microbes. These changes are: improvement in oxygen supply to plant, improvement in activity of aerobic microbes due to supply of oxygen and peptone and improvement in availability of nutrients. It promotes growth of aerobic soil microbe population useful for plant growth and depresses the growth of anaerobic pathogenic microbes in soil. It does not enter the metabolic pathways of crop plant. Thus oxygenated peptone fulfills the criteria for organic farming laid down by International Federation of Organic Agriculture Movement (IFOAM) and at the same time increases crop yield[8-10].

In the view of the above situation, an attempt is made in the present investigation to study yield enhancement in chickpea using soil applied oxygenated peptone under organic farming condition.

Materials and Methods

The earthen pots (40 × 40 cm) were filled with soil and vermicompost in the ratio 10:1 kg/pot. The recommended dose of oxygenated peptone (2 g/pot) was buried in soil of pot. Oxygenated peptone is a white, eco-friendly, non-toxic powder which contains 100 mg/g oxygen, 650 mg/g peptone and 250 mg/g inert filler compound. When applied to soil at the depth of 10 cm and watered, it releases oxygen slowly for 40-50 days continuously. Control plants were raised in pots without oxygenated peptone. Morphological parameters were analyzed at maturity using routine laboratory methods. Minerals were analyzed at maturity using Atomic Absorption Spectrometer.

Total acids, ash, total solids, moisture and crude fiber content were analyzed by methods described by Saini *et al*[11]. Soluble proteins were analyzed by the method proposed by Lowry *et al*[12] while total carbohydrates and ascorbic acid content were analyzed as per methods given by Sadasivam & Manickam[13]. The enzyme activity of amylase (EC 3. 2. 1.1) and catalase (EC 1.11.1.6), was scored by the method of Sadasivam and Manickam[13] and that of protease (EC 3.4. 2. 2) by the method of Penner and Ashton[14]. The data obtained was statistically analyzed using Student's- t test.

Results and Discussion

Table 1 exhibits the effect of oxygenated peptone on root at maturity. The treatment led to the enhancement in length (26.34%) and biomass of root. Fresh weight was increased by 79.88% while dry weight was increased by 93.10%. This is supported by Plate 1 which shows more growth of root system under experimental condition.

Table 2 shows the effect of oxygenated peptone on minerals in root, stem and leaf. It shows increase in major mineral elements like total nitrogen, total phosphorous and total potash. Total nitrogen was found to be increased in root by 2.5%, in stem by 3.26% and in leaf by 18.18%. It is noteworthy here that according to Wani *et al*[15], sustainable agriculture relies greatly on renewable resources like biologically fixed nitrogen and biological nitrogen fixation plays an important role in maintaining soil fertility. Total phosphorous also showed increase in stem as well as in leaf by 19.04 and 13.09%, respectively while it was found to be decreased in root by 26.53 per cent. Total potash exhibited increase in root, stem and leaf by 6.06, 25 and 1.11%, respectively. Chaudhari and Das[16] and Dwivedi *et al*[17] reported that the increased

Table 1—Effect of oxygenated peptone on roots of chickpea (*Cicer arietinum* Linn. cv. 'vijay') at maturity

S No.	Parameter	Non-treated (120 DAS)	Treated (110 DAS)	Increase (%)
1.	Length of root (cm)	12.3 ± 0.75	15.54* ± 1.32	26.34
	Biomass Fresh wt (g)	0.706 ± 0.17	1.27* ± 0.30	79.88
2.	Dry wt (g)	0.292 ± 0.03	0.56* ± 0.008	93.10

Values are mean of twenty determinations; Standard deviation (±); Significance at 5% level (*)

Plate 1—Effect of soil application of oxygenated peptone on root morphology of chickpea (*Cicer arietinum* L. cv. 'vijay') at maturity

Table 2—Effect of soil application of oxygenated peptone on mineral contents in leaf of chickpea (*Cicer arietinum* Linn. cv. 'vijay') at maturity

S. No.	Parameters	Root			Stem			Leaf		
		Control	Treated	Increase (%)	Control	Treated	Increase (%)	Control	Treated	Increase (%)
1.	Total Nitrogen (%)	0.80	0.82	02.5	0.92	0.95	03.26	1.1	1.3	18.18
2.	Total Phosphorous (P_2O_5 %)	0.98	0.72	- 26.53	0.84	1.0	19.04	0.84	0.95	13.09
3.	Total Potash (K_2O %)	1.98	2.1	06.06	2.64	3.30	25.0	1.80	1.92	06.66
4.	Zinc (ppm)	72	40	- 44.44	56	38	- 32.14	50.0	50.0	0.00
5.	Copper (ppm)	30	40	33.33	20	20	0.00	50.0	40.0	- 20
6.	Iron (ppm)	660	1910	189.39	940	1600	70.21	860	3430	298.8
7.	Manganese (ppm)	40	50	25.0	20	40	100	150	160	06.66
8.	Calcium (%)	0.68	0.72	05.88	0.72	0.82	13.88	0.70	0.81	15.71
9.	Magnesium (%)	0.12	0.13	08.33	0.10	0.15	50.0	0.13	0.14	07.69

Table 3—Effect of oxygenated peptone on reproductive growth of chickpea (*Cicer arietinum* Linn. cv. 'vijay') at maturity

S. No.	Parameters	Non-treated	Treated	Increase (%)
1.	Days required for 50% flowering	35	32	-8.57
2.	Days required for harvestation	120	110	-8.33
3.	No. of pods / plant (60DAS)	10.0 ± 1.19	18.9*± 2.68	89
4.	Fresh wt. of 100 pods (g)	51.2 ± 0.07	57.9* ± .06	13.8
5.	Dry wt. of 100 pods (g)	17.2± 1.15	21.40*± 1.62	24.41
6.	Fresh wt. of 100 seeds (g)	41.5± 0.10	48.77*± 0.17	17.51
7.	Dry wt. of 100 seeds (g)	15.26 ± 0.75	18.98*± 0.32	24.37

Values are mean of twenty determinations; Standard deviation (±); Significance at 1 % level (**); Significance at 5% level (*)

uptake of nitrogen, phosphorous and potassium by soybean was associated with the increased protein synthesis of soybean. In present study, the soil aeration using oxygenated peptone played significant role in increasing phosphorous content. It is supported by the observation of Tanaka *et al*[18] who reported that super saturation of dissolved oxygen in culture solution promoted the uptake of phosphorous in tomato. The treatment decreased zinc content in root by 44.44%, in stem by 32.14% and it is found to be stable in case of leaf. Copper was found to be increased in root by 33.3%, stable in stem and decreased in leaf by 20%. Iron showed increase in root and leaf by 189.39% and 298.8%, respectively while it showed decrease by 36.1% in stem. Manganese was increased in root, stem as well as leaf by 25, 100 and 6.66 %, respectively under experimental condition. Calcium also showed increasing trend in root, stem and leaf by 5.88, 13.88 and 15.71%, respectively. Magnesium was also found to be increased in root, stem as well as leaf by 8.33, 50 and 7.69 %, respectively. Increase in calcium and magnesium with higher level of increase of iron in leaf is significant from the nutrition point of view when leaves are consumed as leafy vegetable as in Indian system of cooking. Increased copper content in root is significant as copper is known to kill pathogenic microbes.

The effect of oxygenated peptone on reproductive growth of chickpea is shown in Table 3. Under experimental condition, the days required for 50% flowering and days required for harvestation are found to be decreased by 8.57 and 8.33, respectively. This means that the treatment led to early flowering and early maturation. Incidentally, EI–Zawily *et al*[19], Sorte *et al*[20] and Khedr *et al*[21] also obtained the same effect when the plants were sprayed with GA. Possibly, soil treatment with oxygenated peptone might be leading to endogenous hormone synthesis through enhanced metabolic activities. The other parameters exhibited increase in terms of number of pods per plant (89 %), fresh wt of 100 pods (13.8 %), dry wt of 100 pods (24.41%), fresh wt of 100 seeds (17.51%) and dry wt of 100 seeds (24.37%). The seed characters obtained under experimental condition are remarkable as they show increase in fresh wt and dry wt of 100 seeds which exhibits bigger size, healthy condition and better germination capacity of seeds (Plate 2).

As exhibited in Table 4, the analysis of biochemical constituents of seeds of the plants under experimental condition showed increase in the total solids (39.74%), ash (52.38%), total acids (6.89%), moisture content (50%) and crude fiber content (1.74%). Soluble protein content was increased by 30.99%, total carbohydrates by 7.42% and ascorbic acid (vitamin c) by 45.78%. This is supported by the results obtained in brinjal by Singh *et al*[2] and Singh[22] using biofertilizers and organic manure. Ascorbic acid is a water soluble compound that decreases pace of senescence and maintains biological integrity during ripening by oxidizing ascorbate to di-hydro ascorbate as observed by Murugan and Sumitha[23]. All the parameters shown in Table 4 indicate better nutritional quality of seeds under experimental condition.

The enzymes of seeds of chickpea showed increase in the activity of catalase, peroxidase and polyphenol oxidase under experimental condition at harvestation by 38.29, 34.34 and 14.70%, respectively as shown in the Figure 1. Activity of antioxidant enzymes like super oxide dismutase, catalase and peroxidase increases when plants undergo shift from vegetative to reproductive phase[24]. It has been reported by Lokhande *et al*[25] that during the transition from vegetative to reproductive phase, the level of active oxygen species and antioxidant enzymes increases, suggesting that plants undergo stressful conditions during the flowering process. Catalase enzyme scavenges H_2O_2 during the shift in vegetative to reproductive stage. Anand *et al*[26] reported that the stressful condition generated due to the transition of plant towards the reproductive stage is overcome by the increased antioxidant activity of catalase. There is increased level of polyphenol oxidase in seeds under experimental condition. This is supported by the observation of Murugan and Sumitha[23] who reported higher activity of polyphenol oxidase at ripening which indicates higher metabolic activity at this developmental stage.

Plate 2—Effect of soil application of oxygenated peptone on pod morphology of chickpea (*Cicer arietinum* L. cv. 'vijay') at maturity

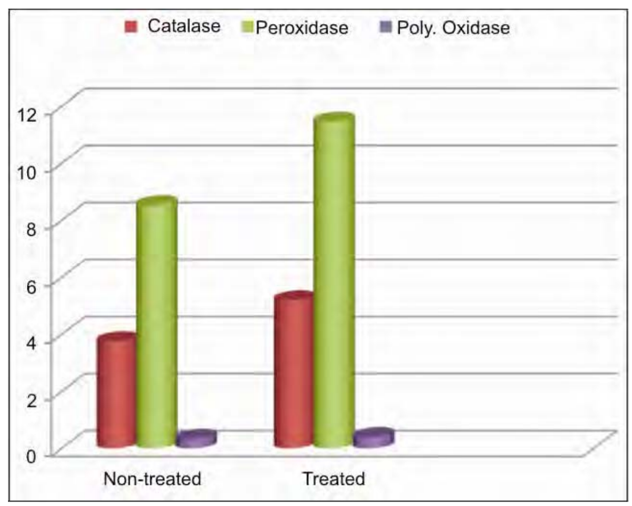

Fig. 1—Effect of soil application of oxygenated peptone on enzyme activity of seeds of chickpea (*Cicer arietinum* L. cv. 'vijay') at maturity

Table 4—Effect of oxygenated peptone on biochemical constituents and enzyme activity of seeds of chickpea (*Cicer arietinum* Linn. cv. 'vijay') at maturity

S. No.	Parameters	Non-treated	Treated	Increase (%)
1.	Total solids (g.)	0.312 ± 0.04	0.436* ± 0.06	39.74
2.	Ash (g)	0.063 ± 0.04	0.096* ± 0.04	52.38
3.	Total acid / Acidity (%)	25.22 ± 2.03	26.98* ± 3.66	6.89
4.	Moisture (%)	2.0 ± 0.28	3.0* ± 0.5	50
5.	Crude fiber content (%)	7.62 ± 0.95	7.75* ± 0.94	1.74
6.	Soluble proteins (g. 100^{-1} g fresh wt.)	4.73 ± 0.96	6.20* ± 0.52	30.99
7.	Total carbohydrates (g. 100^{-1} g fresh wt.)	25.06 ± 0.11	26.92**± 0.70	7.42
8.	Ascorbic acid (mg. 100^{-1}g fresh wt.)	103.3 ± 0.16	150.6* ± 0.35	45.78

Values are mean of three determinations; Standard deviation (±); Significance at 1 % level (**); Significance at 5% level (*)

Soil application of oxygenated peptone plays key role in soil aeration and increases soil oxygen level and soil porosity. As advocated by Muehlig *et al*[27], the oxygen requirement of soil microbes is four times greater than that of root cells. Hypoxic soil conditions lead to decrease in extension, penetration and absorption of nutrients by roots. Improved root growth improves fertilizer use efficiency. Oxygenated peptone reduces the toxicity of reduced metal ions in the soil by oxidizing them. In addition, it avoids soil reduction which is very significant because soil reduction adversely affects growth and biomass accumulation in plants[28]. According to Patil *et al*[6], oxygenated peptone can be used safely in organic farming as it does not enter the metabolic pathways of plant and yet fulfils the conditions of organic farming. Peptone is the soluble source of nitrogen for microbes and plant. The presence of oxygen and peptone in rhizosphere attracts the aerobic microbes from different soil pockets and their population increases in the rhizosphere area. They carry out various processes as per need of the plant. Thus, genetic potential of the plant is better exploited for growth and yield which results in better growth and better yield. This is supported by Morra *et al*[29] who reported that soil amendment using organic compounds led to better yield than by using mineral treatment.

Conclusion

The overall findings revealed that the soil amendment using oxygenated peptone is an easy and eco-friendly technique beneficial for quantitative and qualitative enhancement in yield of chickpea under organic farming condition.

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