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Influence of seed biopriming and organic manure nutrition on okra organic seed production

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ABSTRACT : Investigation was carried to develop nutrient management technology through biopriming with liquid *Azospirillum brasilense* and organic manures, for organic okra (cv. ARKA ANAMIKA) seed production. In, field experiments conducted by adopting Split Plot Design during two seasons. Seed biopriming with *Azospirillum brasilense* (SP 7) @ 15 per cent for 12h and nonprimed seed formed the main plot treatments. Sub plot treatments *viz*., inorganic fertilizers, farm yard manure (FYM), poultry manure (PM), vermicompost (VC) were adopted individually and in combinations. Seed biopriming with *Azospirillum* 15 per cent for 12h with recommended dose of fertilizer registered highest seed yield in both the seasons with a per cent increase of 8 to 12 per cent compared to control plots. Among the organic manures, seed biopriming with *Azospirillum* and 100 per cent RDF through poultry manure recorded higher organic seed yield with an increase of 6 to 7 per cent than control. Adoption of seed biopriming and organic manure nutrition to seed production okra showed the B:C ratio of 1:2.1.

KEY **W**ORDS : *Azospirillum brasilense*, Seed biopriming, Organic manure nutrition, Organic seed

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Green revolution technologies has boosted the production output in most cases. However, continuous use of high energy inputs indiscriminately now leads to decline in production and productivity of various crops as well as deterioration of soil health and environment. Thus, apart from quantity, quality will be the important factor. Such varieties of concern and problems of modern Indian agriculture gave birth to various new concepts of farming such as organic farming, natural farming, biodynamic agriculture, do-nothing agriculture, eco-farming, etc.

To grow and market a product with an organic label, one should use organically produced seed. International federation of organic movement (IFOAM) has clearly laid down the condition that in order to get organic certification to the produces, the seed used for sowing should also have been produced organically (Anonymous, 2002). To enter into organic agriculture, timely research has been warranted to study the strategies and efficacies of organic seed production to fulfill the global organic seed demand.

Organic seed production system involves use of organic seed quality enhancement treatments, integrated organic nutrient management practices *viz.*, organic manures, green manures and biofertilizers etc. and integrated organic plant protection *viz*., agronomic

practices, crop rotation, growing border/trap crops and use of botanicals, biopesticides and biocontrol agents apart from encouraging natural parasites, predators and parasitoids etc.

In organic seed production, seed biopriming can be applied. Biopriming is a process of biological seed treatment that refers combination of seed hydration and inoculation of seed with beneficial organism. It is an ecological approach.

Micro-organisms play an important role in agricultural systems, particularly plant growth-promoting micro-organisms (PGPMs). Plant growth benefits may be attributed mainly to three mechanisms as follow. (i) PGPMs acting as biofertilizers, (ii) Phytostimulators (microbes expressing phytohormones such as *Azospirillum*) can directly promote the growth of plants, usually by producing plant hormones, (iii) Biological control agents.

Organic manures, in general, supplies the essential macro and micronutrient elements to plants, as well as improves soil physico-chemical conditions and biological activity which in turn helps for better growth and development (Hunt and Minnich, 1979).

Keeping the above research gaps in view, a study was taken up with okra cv. ARKA ANAMIKA with the objective of the influence of seed biopriming with liquid *Azospirillum brasilense* (SP7) and organic manure nutrition on the yield and quality of organic seed.

RESEARCH PROCEDURE

In order to realize the objectives the following field experiments were carried out at seed farm of Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore during 2011 - 2013.

Seed priming :

Liquid *Azospirillum* was diluted to 15 per cent concentration. Seeds were soaked in double the volume of *Azospirillum* 15 per cent solution for 12h, removed from the solution, shade dried at room temperature and then, dried under sun to bring back to the original moisture content (Mariselvam, 2012). Seed biopriming with *Azospirillum brasilense* (SP 7) @ 15 per cent for 12h and nonprimed seed formed the main plot treatments.

Organic manure and fertilizer application :

The treatment plots (sub-plots) from S_1 and S_7 were applied with respective organic manures in the required quantities based on 'N' basis and chemical fertilizers individually and their combinations, and incorporated well before seed sowing. Seven sub plot treatments were (i) Recommended dose of fertilizers as inorganic fertilizers, (ii) 100 per cent RDF through farm yard manure (FYM), (iii) 100 per cent RDF through poultry manure (PM), (iv) 100 per cent RDF through vermicompost (VC), (v) 50 per cent FYM + 50 per cent PM, (vi) 50 per cent FYM + 50 per cent VC and (vii) 50 per cent PM + 50 per cent VC.

The organic seed crop was given with organic cultivation practices for raising a healthy crop. After recording field emergence, ten plants were selected randomly from each treatment replication wise for measuring the growth parameters like plant height, days to first flowering, days to 50 per cent flowering, chlorophyll index, leaf area index (LAI) and observations on seed yield and its attributes like fruit length, fruit circumference, fruit weight, seed weight fruit^{-1}, pod to seed recovery, organic seed yield plot^{-1}, organic seed yield ha^{-1}, organic seed recovery and quality of resultant organic seed like hundred seed weight, germination, root length, shoot length, drymatter production, vigour index and benefit cost ratio.

Statistical analysis :

The data obtained from different experiments were analysed for the 'F' test of significance following the methods described by Panse and Sukhatme (1985). Wherever, necessary, the per cent values were transformed to angular (Arc-sine) values before analysis. The critical differences (CD) were calculated at 5 per cent probability level. The data were tested for statistical significance. If the F test was non-significant, it is indicated by the letters NS.

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under following heads :

Field emergence :

Field emergence was significantly influenced by seed biopriming and organic manures in June 2011 and January 2012 seasons (Table 1). Under seed biopriming treatment *i.e.* seed bioprimed with liquid *Azospirillum* @ 15 per cent for 12h (M_2), 100 per cent RDF through poultry

manure (S_3) recorded significantly higher field emergence in both the seasons (93 and 97 %, respectively in June 2011 and January 2012 seasons). Under nonprimed seed (M_1), recommended dose of fertilizer (S_1) registered lower field emergence of 84 and 82per cent, respectively in June 2011 and January 2012 seasons.

Plant height :

The plants produced by the seeds bioprimed with liquid *Azospirillum* @ 15 per cent for12h (M_2) grown under recommended dose of inorganic fertilizer (S_1) registered taller plant of 61.5cm at 90 DAS. The next best treatment was 100 per cent RDF through poultry manure (S_3) which recorded taller plants only at 90 DAS (59.0cm) during June 2011 season. In January 2012 season also, when bioprimed seed (*Azospirillum* @ 15% for 12h (M_2), grown under recommended dose of inorganic fertilizer level (S_1) showed more plant height. Among organic manurial treatment, 100 per cent RDF through poultry manure (S_3) recorded more plant height of 57.5cm at 90 DAS (Table 2).

Leaf area index (LAI) :

In seed biopriming with liquid *Azospirillum* @ 15 per cent for 12h (M_2), recommended dose of fertilizer (S_1) registered higher leaf area index (71.1 at 30 DAS

Table 1: Influence of seed biopriming with *Azospirillum* and organic manure nutrition on field emergence (%) in okra cv. ARKA ANAMIKA under organic field conditions during June 2011 and January 2012

	June 2011				January 2012			
Treatments	M_1	M_2			M_1	M_2	Mean	
S_1	84 (66.42)	85 (67.21)	85 (67.21)		82 (64.89)	87 (68.86)	84 (66.42)	
S_2	86 (68.02)	87 (68.86)	86 (68.02)		88 (69.73)	90 (71.56)	89 (70.63)	
S_3	92 (73.57)	93 (74.66)	92 (73.57)		93 (74.66)	97 (80.02)	95 (77.08)	
S_4	83 (65.65)	90 (71.56)	89 (70.63)		90 (71.56)	93 (74.66)	92 (73.57)	
S_5	86 (68.02)	88 (69.73)	87 (68.86)		83 (65.65)	90 (71.56)	87 (68.86)	
S_6	87 (68.86)	87 (68.86)	87 (68.86)		88 (69.73)	90 (71.56)	89 (70.63)	
S_7	87 (68.86)	88 (69.73)	88 (69.73)		88 (69.73)	92 (73.57)	90 (71.56)	
Mean	87 (68.86)	88 (69.73)	88 (69.73)		88 (69.73)	91 (72.54)	89 (70.63)	
	M	S	M at S	S at M	M	S	M at S	S at M
S.E.±	0.01	0.03	0.04	0.04	0.15	0.14	0.24	0.20
C.D. (P=0.05)	0.06	0.06	0.09	0.08	0.62	0.30	0.69	0.42

Figures in parantheses indicate arc sine values

Main plot treatments :M_1 - Nonprimed seed, M_2 - Biopriming with liquid *Azospirillum* @ 15% for 12h Subplot treatments: S_1 – RDF, S_2 - 100% RDF through farm yard manure (FYM), S_3 - 100% RDF through poultry manure (PM), S_4 - 100% RDF through vermicompost (VC), S_5 - 50% FYM + 50% PM, S_6 - 50% FYM + 50%VC, S_7 - 50%PM + 50%VC

Table 2: Influence of seed biopriming with *Azospirillum* and organic manure nutrition on plant height (cm) in okra cv. ARKA ANAMIKA at harvesting stage under organic field conditions during June 2011 and January 2012

	June 2011				January 2012			
Treatments	M_1	M_2	Mean		M_1	M_2	Mean	
S_1	58.0	60.0	59.0		78.5	80.5	79.5	
S_2	52.0	54.5	53.3		71.5	72.3	71.9	
S_3	56.0	57.5	56.8		75.0	76.5	75.8	
S_4	55.7	57.0	56.4		74.5	75.2	74.9	
S_5	53.0	54.2	53.6		73.0	74.2	73.6	
S_6	54.0	54.9	54.5		73.5	74.2	73.9	
S_7	55.0	56.0	55.5		73.5	74.3	73.9	
Mean	54.8	56.3	55.6		74.2	75.3	74.8	
	M	S	M at S	S at M	M	S	M at S	S at M
S.E.±	0.05	0.07	0.11	0.10	0.05	0.14	0.20	0.20
C.D. (P=0.05)	0.22	0.15	0.27	0.21	0.23	0.30	0.44	0.42

during June 2011 season). Among the organic manurial treatments, 100 per cent RDF through poultry manure (S_3) recorded higher leaf area index of 68.3 at 30 DAS. Under nonprimed seed (M_1), 100 per cent RDF through farm yard manure (S_2) recorded lesser value (64.1at 30DAS).In January 2012 season also, under seed biopriming with liquid *Azospirillum* @ 15 per cent for 12h (M_2), recommended dose of fertilizer (S_1) registered higher leaf area index, followed by 100 per cent RDF through poultry manure (S_3) (67.5 at 30 DAS) (Table 3).

Pod to seed recovery :

The interaction effect between seed biopriming and organic manures had a significant influence in both the seasons with respect to pod to seed recovery. Under seed biopriming with liquid *Azospirillum* @ 15 per cent for 12h (M_2), 100 per cent RDF through poultry manure (S_3) registered morepod to seed recovery (78 and 79%) in both the seasons (Table 4).

Organic seed yield :

The interaction effect between seed biopriming and organic manures was significant in both the seasons on organic seed yield. Under seed biopriming with liquid *Azospirillum* @ 15 per cent for 12h (M_2), recommended dose of inorganic fertilizer (S_1) registered higher organic seed yield (729.4 and 706.5 $kgha^{-1}$, respectively in June 2011 and January 2012

Table 3: Influence of seed biopriming with *Azospirillum* and organic manure nutrition on leaf area index (LAI) in okra cv. ARKA ANAMIKA at vegetative stage under organic field conditions during June 2011 and January 2012

	June 2011				January 2012			
Treatments	M_1	M_2	Mean		M_1	M_2	Mean	
S_1	69.5	71.1	70.3		67.5	69.1	68.3	
S_2	64.1	65.2	64.7		62.0	64.3	63.2	
S_3	67.5	68.3	67.9		65.6	67.5	66.6	
S_4	67.3	67.9	67.6		65.2	66.6	65.9	
S_5	66.5	67.0	66.8		64.5	66.3	65.4	
S_6	66.3	66.7	66.5		64.4	66.4	65.4	
S_7	66.4	66.9	66.7		64.0	66.5	65.3	
Mean	66.8	67.6	67.2		64.7	66.7	65.7	
	M	S	M at S	S at M	M	S	M at S	S at M
S.E.±	0.05	0.10	0.14	0.14	0.03	0.03	0.05	0.05
C.D. (P=0.05)	0.23	0.21	0.34	0.30	0.14	0.07	0.16	0.09

Table 4 : Influence of seed biopriming with *Azospirillum* and organic manure nutrition on pod to seed recovery in okra cv. ARKA ANAMIKA under organic field conditions during June 2011 and January 2012

	June 2011				January 2012			
Treatments	M_1	M_2	Mean		M_1	M_2	Mean	
S_1	55 (47.87)	60 (50.77)	58 (49.60)		54 (47.29)	62 (51.94)	58 (49.60)	
S_2	60 (50.77)	62 (51.94)	61 (51.35)		59 (50.18)	60 (50.77)	60 (50.77)	
S_3	75 (60.00)	78 (62.03)	77 (61.34)		77 (61.34)	79 (62.72)	78 (62.03)	
S_4	65 (53.73)	70 (56.78)	68 (55.55)		70 (56.78)	72 (58.05)	71 (57.42)	
S_5	63 (52.53)	65 (53.73)	64 (53.13)		65 (53.72)	65 (53.72)	65 (53.72)	
S_6	60 (50.77)	62 (51.94)	61 (51.35)		60 (50.77)	62 (51.94)	61 (51.35)	
S_7	60 (50.77)	63 (52.53)	62 (51.94)		62 (51.94)	66 (54.33)	64 (53.13)	
Mean	63 (52.53)	66 (54.33)	64 (53.13)		64 (53.13)	67 (54.94)	65 (53.73)	
	M	S	M at S	S at M	M	S	M at S	S at M
S.E.±	0.18	0.36	0.51	0.51	0.08	0.21	0.28	0.29
C.D. (P=0.05)	0.78	0.75	1.20	1.06	0.34	0.43	0.63	0.61

seasons). Among the organic treatments, 100 per cent RDF through poultry manure (S_3) recorded higher organic seed yield (550.7 and 545.5 kgha^{-1}, respectively during both the seasons) (Table 5).

Resultant seed quality :

Germination :

From the interaction effect, it was observed that in seed bioprimed with liquid *Azospirillum* @ 15 per cent for12h (M_2), 100 per cent RDF through poultry manure (S_3) and 100 per cent RDF through vermicompost (S_4) registered higher germination (92%) during June 2011 season. For nonprimed seed (M_1), recommended dose of fertilizer (S_1) recorded lower germination of 77 and 78 per cent during June 2011 and January 2012 seasons, respectively. In January 2012 season, 100 per cent RDF through poultry manure (S_3) application alone registered higher germination of 92 per cent, under seed bioprimed with liquid *Azospirillum* @ 15 per cent for12h (M_2) (Table 6).

Vigour index :

The interaction effect recorded that under seed biopriming with liquid *Azospirillum* @ 15 per cent for12h (M_2), 100 per cent RDF through poultry manure (S_3) and 100 per cent RDF through vermicompost (S_4) recorded vigour index of 3090 and 3095 during June 2011 season. In January 2012 season also, 100 per cent RDF through poultry manure (S_3) and 100 per cent RDF through vermicompost (S_4) recorded vigour index of 3050 and

Table 5 : Influence of seed biopriming with *Azospirillum* and organic manure nutrition on organic seed yield ha^{-1} in okra cv. ARKA ANAMIKA under organic field conditions during June 2011 and January 2012

	June 2011				January 2012			
Treatments	M_1	M_2	Mean		M_1	M_2	Mean	
S_1	649.4	729.4	689.4		654.5	706.5	680.5	
S_2	418.7	436.4	427.5		394.8	426.0	410.4	
S_3	521.6	550.7	536.1		509.1	545.5	527.3	
S_4	498.7	519.5	509.1		477.9	519.5	498.7	
S_5	439.5	467.5	453.5		431.2	448.8	440.0	
S_6	429.1	441.6	435.3		426.0	436.4	431.2	
S_7	446.8	462.3	454.6		436.4	457.1	446.8	
Mean	486.2	515.3	500.8		475.7	505.7	490.7	
	M	S	M at S	S at M	M	S	M at S	S at M
S.E.±	0.34	1.07	1.44	1.52	0.35	1.08	1.45	1.52
C.D. (P=0.05)	1.45	2.21	3.15	3.13	1.49	2.22	3.18	3.15

Table 6 : Influence of seed biopriming with *Azospirillum* and organic manure nutrition on seed quality of resultant organic seed in okra cv. ARKA ANAMIKA under organic field conditions during June 2011 and January 2012

	June 2011				January 2012			
Treatments	M_1	M_2	Mean		M_1	M_2	Mean	
S_1	77 (61.34)	80 (63.43)	79 (62.72)		78 (62.01)	80 (63.43)	79 (62.72)	
S_2	87 (68.86)	88 (69.93)	88 (69.93)		88 (69.73)	90 (71.56)	89 (70.63)	
S_3	90 (71.56)	92 (73.57)	91 (72.54)		89 (70.63)	92 (73.57)	91 (72.54)	
S_4	90 (71.56)	92 (73.57)	91 (72.54)		88 (69.73)	90 (71.56)	89 (70.63)	
S_5	88 (69.93)	90 (71.56)	89 (70.63)		87 68.86)	90 (71.56)	89 (70.63)	
S_6	86 (68.02)	88 (69.93)	87 (68.86)		87 (68.86)	89 (70.63)	88 (69.73)	
S_7	88 (69.93)	90 (71.56)	89 (70.63)		88 (69.73)	90 (71.56)	89 (70.63)	
Mean	87 (68.86)	89 (70.63)	88 (69.93)		86 (68.02)	89 (70.63)	88 (69.73)	
	M	S	M at S	S at M	M	S	M at S	S at M
S.E.±	0.07	0.17	0.24	0.24	0.07	0.11	0.16	0.16
C.D. (P=0.05)	0.32	0.35	0.54	0.50	0.29	0.23	0.39	0.33

3040. Under nonprimed seed (M_1), recommended dose of fertilizer (S_1) recorded lower vigour index of 2500 and 2650 in two seasons, respectively (Table 7).

Several indigenous practices are in vogue in India which is being promoted in recent past. After knowing the ill effects posed by chemical fertilizers and insecticides on the beneficial fauna and to the living beings, there is great awakening to look back the olden days of agriculture. Investigations are required to emerge with suitable indigenous technology on every crop, especially vegetables which are consumed daily (raw or cooked) in large scale. To overcome the ill effects of chemical in agriculture, organic farming can be a solution.

The field emergence of okra seeds was higher due to seeds bioprimed with *Azospirillum* 15 per cent for 12h when grown under 100 per cent RDF through poultry manure, which showed an increase of 1.1 and 3 per cent over nonprimed seed grown under 100 per cent RDF through poultry manure, respectively during June 2011 and January 2012 seasons. When compared to nonprimed seed grown with recommended dose of fertilizers, the increases in field emergence for this treatment were 1.2 and 6.1 per cent, respectively in June 2011 and January 2012 seasons.

The significant improvement in field emergence due to seed biopriming with liquid *Azospirillum* 15 per cent for 12h could be possible because of the production of germination accelerating and growth promoting substances by the liquid *Azospirillum*. Morgenstern and Okon (1987) reported that auxin, gibberellin and cytokinin are synthesised and produced when the seeds are inoculated with *Azospirillum*.

Priming allows the metabolic processes necessary for germination to occur without actual germination. Primed seeds usually exhibit an increased germination rate, greater germination uniformity and higher total germination percentage (Basra *et al.*, 2005). This may be due to increase in activity of enzymes such as α-

Table 7: Influence of seed biopriming with *Azospirillum* and organic manure nutrition on seed quality of resultant organic seed in okra cv. ARKA ANAMIKA under organic field conditions during June 2011 and January 2012

	June 2011				January 2012			
Treatments	M_1	M_2	Mean		M_1	M_2	Mean	
S_1	2500	2570	2535		2650	2750	2700	
S_2	2870	2880	2875		2850	2890	2870	
S_3	3080	3090	3085		3010	3050	3030	
S_4	3075	3095	3085		3025	3040	3033	
S_5	2975	2995	2985		2890	2950	2920	
S_6	2960	2980	2970		2900	2950	2925	
S_7	2963	2983	2973		2920	2960	2940	
Mean	2918	2942	2930		2892	2941	2917	
	M	S	M at S	S at M	M	S	M at S	S at M
S.E.±	0.4	3.3	4.3	4.6	1.4	3.3	4.5	4.6
C.D. (P=0.05)	1.8	6.8	9.0	9.6	6.1	6.8	10.3	9.6

Table 8 : Cost economics for organic seed (Biopriming with *Azospirillum* 15% for 12h + 100% RDF through poultry manure) and conventional seed (Nonprimed seed + recommended dose of fertilizer)

Particulars	Organic seed (Rs.)	Conventional seed (Rs.)
Total direct cost	58672	39886
Total indirect cost	8000	8000
Total cost	66172	47386
Total returns	206625	218700
Net return	140454	17135
Cost per kg	121	91
Price per kg	375	300
Net return per kg	254	209
Benefit cost ratio	2.1	2.3

amylase, protease and lipase which have a great role in breakdown of macromolecules for growth and development of embryo that ultimately resulted in early and higher seedling emergence.

Hence, *Azospirillum* seed treatment has would have helped in the germination of seed to undergo rapid and fast metabolic processes and increased production of phytohormones which accelerated the rapid and quick emergence of radicle and plumule as well as stronger and larger root system and this has resulted in increased field emergence and stand establishment.

The effect of *Azospirillum* was highly pronounced when seeds bioprimed with *Azospirillum* were grown with the application of 100 per cent RDF through poultry manure. Application of poultry manure recorded higher seed germination due to supply of phosphorus readily to the germinating seeds and creating suitable soil environmental conditions such as reducing the soil bulk density and temperature and by increasing the total porosity and moisture content of soil (Ahmad *et al.*, 2012; Garg and Bahla, 2008 and Ojeniyi *et al.*, 2013).

The plants produced by the seeds bioprimed with *Azospirillum* when grown with recommended dosage of fertilizers were taller by 2.2 to 3.5 per cent at 90 DAS compared to non-prime seeds during both the seasons. Among the organic manures, poultry manure out performed other organic manure in enhancing the plant growth by 1.2-2.7 per cent increase compared to control.

In the present study, leaf area index was also more in the plants grown from the bioprimed seed with *Azospirillum* and applied with recommended fertilizer dose and seed biopriming plus 100 per cent RDF through poultry manure

The genus *Azospirillum* are nitrogen-fixing organisms that live in close association with plants in the rhizosphere. Upon *Azospirillum* inoculation, an alter in root morphology was observed which has been ascribed to the bacterial production of plant growth regulating substances (Umalia-Garcia *et al.*, 1980).

For organic seed production, application of poultry manure to the bioprimed seed could able to contribute added advantage in increasing the plant height and leaf area index when compared to farm yard manure and vermicompost in this study. A plethora of literature indicated that organic manures are rich in labile carbon fractions and its addition to the soil act as a source of energy for microbial population that encourages proliferation of soil micro-organism, increased microbial populations and activity of microbial enzymes *i.e.*, dehydrogenase, urease and nitrogenase (Papavizas and Lumsden, 1982; Abdel-Magid *et al.*, 1996 and Bakry *et al.*, 2009). Therefore, it is presumed that the poultry manure applied to the *Azospirillum* bioprimed seed had encouraged the PGPR to multiply in larger quantities and colonize better along with other beneficial micro-organisms in the rhizosphere of the plants. This has resulted in deeper and stronger root growth which mobilized the efficient uptake of nutrients and water by the plants for better growth and development.

The seed yield was the highest (729.4 and 706.5 kg ha^{-1}, respectively in June 2011 and January 2012 seasons) in the bioprimed seed with *Azospirillum* 15 per cent for 12h when grown under recommended doses of fertilizers, which accounted for 12 and 8 per cent increase over nonprimed seed grown under recommended doses of fertilizers. Among the organic source of manures, poultry manure when applied to bioprimed seed excelled better and recorded higher seed yield of 550.7 and 545.5 kg ha^{-1}, respectively in June 2011 and January 2012 seasons. When compared to nonprimed seed grown under poultry manure nutrition, the yield increases for this treatment were 6 and 7 per cent, respectively during June 2011 and January 2012 seasons. From the previous studies, it was observed that *Azospirillum* inoculation significantly increased the yield of several crops upto 30 per cent (Sumner, 1990; Okon and Labandera-Gonzalez, 1994 and Dalla *et al.*, 2004). Swedrzynska (2000) recorded an yield increase of 1-27 per cent in wheat and 2-6 per cent in oat due to *Azospirillum* inoculation.

A phenominal increase in organic seed yield was noticed in the *Azospirillum* bioprimed seed when grown under poultry manure nutrition. Channabasanagowda *et al.* (2008) in wheat, Ogbonna and Umar-Shaba (2012) in sesamum and Zamil *et al.* (2004) in mustard recorded an increased yield due to application of poultry manure. Application of manures sustains cropping system through better nutrient recycling (El-Shakweer *et al.*, 1998). Akande *et al.* (2011) also noted that large populations of micro-organisms are introduced to the soil through organic manure which promoted N fixation and P solubilization. All these contributed to the enhancing effect of growth and yield attributes obtained from the poultry manure application. Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect (Sharma and Mittra, 1991).

The organic seed and seedling qualities were higher in the resultant organic seed obtained from the seed biopriming with *Azospirillum* 15 per cent for 12h when grown under 100 per cent RDF through poultry manure and vermicompost.

Biofertilizer inoculation either through soil/or seed or root was found to increase the germination of resultant seed in several crops. In tomato, Thakur *et al.* (2012) recorded higher germination (83 to 86 %) in the resultant organic seeds obtained from the plants inoculated with *Azospirillum*, PSB and *Mycorrhiza* when compared to uninoculated control (78 %). Similarly, Lamo *et al.* (2012) in radish, also recorded higher germination of organic seed received from the plots treated with root dipping of PSB or *Azotobacter* or *Azospirillum*. The enhanced seed quality attributes of organic seed received from *Azospirillum* biopriming might be attributed that the plant growth hormones produced by them and solubilization of inorganic nutrients had resulted in enhanced carbohydrate metabolism, greater accumulation of food reserves into the seed and ultimately, the production of good quality seed associated with higher germination and vigour.

The enhanced germination and vigour of organic seed due to application of poultry manure and vermicompost observed in this study are in good agreement with the results of Maheshbabu *et al.* (2008) in soybean, Channabasanagowda *et al.* (2008) in wheat, Agba Oliver Agba *et al.* (2012) in maize and Lamo *et al.* (2012) in radish.

The benefit cost ratio worked out for organic seed and conventional seed indicated that high B:C ratio of 1:2.3 was recorded for conventional seed obtained from the treatment involving nonprimed seed and recommended dose of fertilizers. For organic seed, the B:C ratio was 1:2.1 for the treatment involving biopriming with *Azospirillum brasilense* 15 per cent for 12h and application of 100 per cent RDF through poultry manure (Table 8).

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