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ORGANIC MANURES AND BIOFERTILIZERS ON NUTRIENT AVAILABILITY AND YIELD IN BLACK PEPPER

The demand for organic spices in the international market shows an upward trend and consumers are willing to pay a premium price for organic produces against conventional products. There is very good scope for production and export of organic spices, especially black pepper from India, thereby earn considerable foreign exchange. Black pepper is a crop responding to heavy dozes of organic manures. Biofertilizers can supplement the chemical fertilizers for meeting the nutrient needs and help in improving yield and quality of crop plants. Since no detailed investigations integrating the use of organics, inorganics and biofertilizers have so far been conducted in this crop, the study was undertaken to evaluate their influence on yield and quality improvement along with soil nutrient availability.

The experiment was conducted on eight-year-old pepper vines Panniyur 1 (P_1) and Panniyur 2 (P_2) in RBD with nine replications during 2000-2001. There were 13 treatments as listed below:

- T_1 - 50 % N as farmyard manure (FYM) + *Azospirillum* + phosphate solubilizing microorganisms (P solubilizers) + arbuscular mycorrhizal fungi (AMF) + 100 % K as inorganic
- T_2 - 50% N as FYM + *Azospirillum* + P solubilizers + AMF + 100% K as wood ash
- T_3 - 50% N as FYM + 50% N as neem cake + 100% P and K as inorganic
- T_4 - 50% N as FYM + *Azospirillum* + 100% P and K as inorganic
- T_5 - 50% N as FYM + *Azospirillum* + 50% P as inorganic + P solubilizers + 100% K as inorganic
- T_6 - 50 % N as FYM + 50% N and 100 % P and K as inorganic
- T_7 - 50% N as FYM + 50% N as inorganic + P solubilizers + 100% K as inorganic
- T_8 - 50% N as FYM + 50% N and P and 100% K as inorganic
- T_9 - 50% N as FYM + 50% N and P as inorganic + *Azospirillum* + P solubilizers + AMF + 100% K as inorganic
- T_{10} - 50% N as FYM + 50% NP as inorganic + *Azospirillum* + 100% K as inorganic
- T_{11} - 50% N as FYM + 50% NP as inorganic + P solubilizers + AMF + 100% K as inorganic
- T_{12} - Recommended package of practices
- T_{13} - Control (no fertilizers)

Table 1. Organics and biofertilizers on yield

Treatments	Dry yield (kg vine^{-1})	
	Panniyur 1	Panniyur 2
T_1	0.819	1.336
T_2	1.257	1.169
T_3	0.836	1.510
T_4	1.032	1.579
T_5	1.001	2.077
T_6	1.323	1.034
T_7	1.054	1.136
T_8	0.757	0.751
T_9	1.355	1.427
T_{10}	1.127	0.956
T_{11}	0.934	1.152
T_{12}	1.216	1.097
T_{13}	1.088	1.284
Mean	1.072	1.284
CD (0.05)	NS	NS

Commercial cultures biofertilizers were procured from TNAU, Coimbatore and applied at the rate of 25 g vine^{-1}. The quantities of N, P and K were fixed based on the recommended package of practices for the crop (50:50:150 g NPK vine^{-1} year^{-1}) and applied as urea, mussooriephos and muriate of potash. Dry berry yield vine^{-1} was calculated by multiplying the green berry weight with drying percentage. Recommended standard procedures were followed for the estimation of P. In the first year of harvest, application of organic and inorganic manures in cardamom did not give any difference among treatments, but in subsequent years, treatments registered significant variation in yield (AICRPS, 2000). Treatment 9 in P_1 and treatment 5 in P_2 recorded higher yields. Application of *Azospirillum* and chemical fertilizers as N, P and K in addition to FYM resulted in the highest dry berry yield in pepper (Kanthaswamy *et al.*, 1996). Results of three-year study in clove and nutmeg also gave similar results (AICRPS, 2000). Availability of macronutrients of soil exhibited significant difference among treatments (Tables 2 and 3).

Table 2. Organics and biofertilizers on soil nutrients (N, P and K)

Treatments	Available N (kg ha^{-1})		Available P (kg ha^{-1})		Exchangeable K (kg ha^{-1})	
	P_1	P_2	P_1	P_2	P_1	P_2
T_1	432 ^{abc}	397 ^{cd}	50.5 ^{abc}	51.7"	484 ^{bc}	458 ^{c}
T_2	416 ^{bcd}	402 ^{bc}	55.7 ^{a}	52.4 ^{a}	*560"*	562 ^{a}
T_3	405 ^{def}	398 ^{bcd}	45 9bed	47.7 ^{ab}	392 ^{ef}	428 ^{cdef}
T_4	436 ^{ab}	412 ^{bc}	41.5 ^{d}	42.5 ^{cd}	423 ^{ab}	512 ^{b}
T_5	431 ^{abc}	413 ^{bc}	52.5 ^{ab}	48.5 ^{ab}	470 ^{bcd}	396 ^{ef}
T_6	388 ^{ef}	411 ^{bc}	45 9bed	38.7 ^{d}	422 ^{def}	470 ^{bcd}
T_7	386 ^{f}	402 ^{bc}	51.7 ^{abc}	50.5 ^{ab}	422 ^{def}	412 ^{def}
Tg	410 ^{cde}	404 ^{bc}	43.8 ^{cd}	37.6 ^{d}	455 ^{ab}	525 ^{ab}
T_9	432 ^{abc}	446 ^{a}	52.2 ^{ab}	51.4"	520 ^{ab}	540 ^{ab}
T_{10}	438 ^{ab}	438 ^{a}	46.5 ^{bcd}	51.3 ^{a}	520 ^{ab}	479 ^{bcd}
T_{11}	441 ^{a}	454 ^{a}	42.5 ^{d}	52.5 ^{a}	571 ^{a}	563 ^{a}
T_{12}	410 ^{cde}	404 ^{bc}	39.6 ^{d}	45.7 ^{bc}	444 ^{ede}	449 ^{cd}
T,3	409 ^{cdef}	417 ^{b}	39.7 ^{d}	40.5 ^{d}	392 ^{e}	434 ^{cde}
Mean	415	413	46.3	47.0	475	479
CD (0.05)	23.3	20.3	6.93	5.00	55.5	41.6

Table 3. Organics and biofertilizers on soil nutrients (Ca, Mg and S)

Treatments	Exchangeable Ca (ppm)		Exchangeable Mg (ppm)		Available S (ppm)	
	P_1	P_2	P_1	P_2	P_1	P_2
T,	279 ^{abc}	209	86.9	89.3 ^{bcd}	32.5	29.6
T_2	212 ^{cd}	254	93.6	111.3 ^{abcd}	33.9	30.2
T_3	345 ^{a}	255	108.0	108.0 ^{abcd}	21.5	26.5
T_4	333 ^{ab}	231	93.6	99 8 ^{bcd}	32.3	32.4
T_5	329 ^{ab}	250	87.4	106.1 ^{abcd}	24.8	28.9
T_6	217 ^{cd}	245	87.5	74.8 ^{d}	30.8	30.6
T_7	334•	245	87.4	121.1 ^{abc}	26.9	27.1
T_8	234 ^{cd}	239	74.9	74.8 ^{d}	24.9	27.6
T,	276 ^{abc}	256	87.4	137.3 ^{a}	34.1	31.8
T_{10}	194 ^{d}	226	99.8	87.4 ^{cd}	26.0	27.0
T_{11}	255 ^{bcd}	221	124.8	124.8 ^{ab}	30.2	30.2
T_{12}	186 ^{d}	192	99.8	118.6 ^{abc}	31.0	29.8
T_{13}	208 ^{cd}	208	99.8	87.4 ^{cd}	28.5	28.2
Mean	262	21	94.7	103.1	29.0	29.2
CD (0.05)	77.6	NS	NS	36.9	NS	NS

Table 4. Pre-experiment soil nutrient status and 't' statistic for comparison with post experiment values

Nutrient	Pre-experiment soil nutrient status		't' statistic	
	Panniyur 1	Panniyur 2	Panniyur 1	Panniyur 2
N, kg ha^{-1}	417	403	0.351^{NS}	3.00**
P, kg ha^{-1}	46.5	45.3	0.234^{NS}	1.75^{NS}
K, kg ha^{-1}	472	472	0.277^{NS}	0.654^{NS}
Ca, ppm	273	238	0.974^{NS}	0.414^{NS}
Mg, ppm	112	112	4.03**	2.15**
S, ppm	28.3	29.9	0.791^{NS}	1.13^{NS}

NS = not significant; ** Significant at 1% level

Soil N content showed superiority in T_{11} (FYM, biofertilizers and inorganics) in both the varieties (441 and 454 kg ha^{-1} respectively in P_1 and P_2) and was on par with T_9 and T_{10}. The increased nitrogen availability in the aforesaid treatments might have been due to favourable effect of *Azospirillum* and combination of biofertilizers. The saving of 33 per cent fertilizer nitrogen due to *Azospirillum* inoculation has been proved in ginger (Patil and Konde, 1988). Available P was higher (55.7 kg ha^{-1}) in T_2 (complete organic) in the variety P_1, whereas in P2, T|, T_2, T_9, T_{10} and T_{11}, all containing biofertilizers exhibited higher quantity. The treatments, T_2 (complete organic), T_5, T_7 and T_9 (biofertilizer treatments) recorded higher values in P_1 and P_2. All these treatments contained P solubilizers. P solubilizers in acid soils (pH 5-6.5) help in solubilizing the insoluble phosphates and make it available to the plant (AICRPS, 2000). The significant improvement of available P in T_2 and T_9 can be attributed to the favourable effect of AMF. Phosphate solubilizing bacteria survived longer around mycorrhizal roots of maize plants and acted synergistically with mycorrhiza (Azcon *et al.*, 1976). With respect to K availability, T_{11} (571 kg ha^{-1}) and T_2 (560 kg ha^{-1}) were superior in P_1 These were also on par with T_4, T_9 and T_{10}. In the case of P_2 also, T_{11} (563 kg ha^{-1}) and T_2 (562 kg ha^{-1}) expressed higher K status. The higher K in T_2 might have been due to the effect of wood ash. Enhanced calcium, magnesium and potassium contents in the soil with wood ash application were reported by Gautry (2000) in chestnut. The reason for K improvement in T_9 and T_{11} can be attributed to the synergistic effect of different biofertilizers.

Soil secondary nutrients, except S showed treatment difference. Treatment 3 (FYM + neem cake + inorganics) and treatment 7 (FYM + biofertilizers + inorganics) expressed superiority with regard to exchangeable Ca in P_1 (345 ppm and 334 ppm respectively in T_3 and T_7). In the case of Mg, T_9 (FYM + biofertilizers + inorganics) exhibited maximum value (137.3 ppm). Since secondary nutrients did not form part of treatments, the observed variability may be attributed to that existed in the experimental field. Magnesium being highly mobile in the soil, leaching loss due to heavy rains may be also contributed to its variation in different treatments. Pre- and post-experiment soil nutrient status was compared using 't' test (Table 4). The nutrients, N, P and K have increased after the experiment though not significant except N. Magnesium content showed reduction after treatment while the level of Ca and S was not significant. Since it takes a period of two to three years for getting conclusive results in case of experiments using organics and biofertilizers, exact change in the level of nutrients cannot be known after the first year of study.

The results indicated that treatments involving complete organic and biofertilizer + organic + inorganic combinations exhibited higher values of all the soil nutrients. In general, yield improvement is not usually expected with organics and biofertilizers. However, organic cultivation being more expensive, the higher cost of production could be compensated by the premium price for the organic produce especially in an export oriented crop like black pepper.

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