Effect of Effective Microorganism (EM) Application and Mulching on The Yield of Japanese Pole Bean (*Phaseolus vulgaris*)

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ABSTRACT

The experiment was conducted with the main objective to determine effect of EM and mulching on the yield of beans at ARDC -Samtenling. The trial was laid in RCBD with four treatments in various combinations of mulching and EM application. EM was applied at the rate 40ml per litre of water at the time of sowing and later foliar application was done fortnightly till the crops were harvested. Yield data, 50% anthesis, days to maturity, pod weight, pod length and pod diameter were recorded. It was observed that treatment T_1 (plastic mulch with EM application) was highest with average yield of 9.68MT per acre followed by T_3 (paddy straw mulch with EM application) with 9.00MT. The Yield for treatment T_2 (plastic mulch without EM application) is 7.29MT/acre. The performance of the control (T_0-without mulch and without EM application) was lowest (4.61MT/acre) with significant difference from the rest of the treatment. There was a positive effect on the germination with highest germination percentage in T1 (99.2%); but there were no significant differences among the treatments. There is no significant effect on the growth parameters, although they performed well with EM application and mulching. EM and mulching had negative effect on number of plants reaching 50% anthesis and days to maturity. To understand the effect of EM alone (and not in combination with mulching), further research is required on the different methods and rates of EM application and its action. Information is also required to establish the role of EM in phenotypic changes crop growth, nutrient content and shelf life of the produce.

Keywords: *Effective Microorganism, Germination percentage, Growth, Yield*

1. Introduction

FiBL & IFOAM (2019) reports that the future of agriculture is intrinsically tied to better stewardship of the natural resources base on which it depends. With increasing scarcity of resources, investment in agriculture has to be managed sustainably so that it is environmentally friendly, economically viable and that it enhances the quality of life. Conventional farming heavily relies on synthetic chemical fertilizers that are costly, unsustainable, and hazardous to health and environment. It is estimated that the United States alone is spending USD10 billion per year on environmental and health care due to use of chemicals (Pimentel et al., 2005). It is claimed that organic farming is more efficient and use 45% less energy in contrast to conventional farming that

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produce 40% green-house gases (Muscanescu, 2013). Over the years people have realized the ill-effects of convention farming and are now shifting towards organic and conservative forms of farming. As of 2017, an estimated 69.8 million of hectares of farms have been brought under organic cultivation with Oceania being the largest (35.9 million hectares) followed by Europe (14.6 million ha) and Latin America (8 million ha) (FiBL & IFOAM, 2019).

The major components of organic farming are manuring, green manuring, mulching, intercropping and integrating microorganism in farming that includes technology like EM, bio-fertilizer, entomopathogen, etc.). Effective microorganism (EM) is the culture of group of beneficial and naturally occurring microorganisms like yeast, lactic acid bacteria, actinomycetes, photosynthetic bacteria and fungi. The concept and the use of those beneficial microorganism was first developed by Professor Teuro Higa of the University of the Ryukyus, Okinawa,Japan, in the early 1980s with the purpose to improve soil health and crop production (Mandalaywala, Patel, & Trivedi, 2017). The culture is usually applied as inoculant to increase the microbial activity of soil and plant. Many researchers have shown that soil and plant application of EM has improved soil health and plant growth resulting high crop yield. The application of EM is not only used in soil and farming but also much exploited in waste restoration and management.Therefore, introduction of mixed beneficial and effective microorganism favours growth, yield and health of crops (Higa & Parr, 1994).

In parallel with organic farming, mulching is another form of conservational farming where many researcher and field data support its role in water conservation and increasing crop production. For instance, significant increase in potato yield was observed with organic mulching (50.226MT/ha) as compared to conventional farming (Momirovic, Misovic, & Brocic, 1997). Percentage soil moisture, vegetative growth and yield were significantly higher in organic mulched banana plots as reported by Bananuka, Rubaihayo & Zake (2000). Plastic mulching is also found to increase yield in okra (8332 kg/ha) with water saving of 52.22% against non-mulching with average yield of 7575 kg/ha and water saving of 31.00% only (Memon et al., 2018). Haque, Jahiruddin & Clarke (2018) reports that plastic mulch can be a suitable tool for enhancing maize production and to maintain good soil health in saline soil. They found the use of plastic mulch to greatly reduce excessive availability of sulphur.

Therefore, study on the effect of soil and foliar application of EM on the yield of Japanese Bean was initiated at Agriculture Research and Development Center, Samtenling. EM technology in Bhutan was introduced by Ministry of Agriculture in the year 1993 and was used in field crops, horticulture and livestock in research centers (Chettri, Thinley, & Chado, n.d). Bean is one of the main vegetables being cultivated in Bhutan. In addition, with the ban of import of vegetables like chili, cauliflower and beans due to high chemical residue, there is a need to findways to increase bean production organically. Further, Bhutan being a small country, Department of Agriculture is focusing on organic production.For the 12th Five Year Plan, organic agriculture is one of flag ship programs implemented by the Department of Agriculture. Khalid et al. (2010) affirmed that application of chemical fertilizer (NPK) deteriorates the microflora inhabiting in the soil while EM application increase the microbial density in the soil. Department of Agriculture with a vision of self-reliant and sustainable agriculture, EM production of vegetableswith mulching technology can be one best approach to organic agriculture and natural farming.

2. Materials and method

2.1. Location

The experiment was conducted in Agriculture Research and Development Center (ARDC), Samtenling in the month of September for two consecutive years (2017 and 2018). The experimental site is located at 26.90^o N and 90.343^o E and experiences sub-tropical climate with an elevation of 375 m asl. The average maximumtemperature in the month of September is 32.5^{o}C and mean minimum temperature is 19.5^o C. The average monthly precipitation is 1032mm with a relative humidity of 92.8% (NCHM, 2018). The texture of the soil at experimental site is sandy loam.

2.2.Treatment and design

The experiment with four treatments was laid out in a randomized complete block design (RCBD) with five replications. The treatments were: T_1- plastic mulch with EM application, T_2- plastic mulch without EM application, T_3-paddy straw mulch with EM application and T_0-without mulch and without EM application (Control). For the experiment, beans were sown on the 5th of May by dibbling manually. The plot size maintained for the trial was 3m x 2m and seeds were sown at spacing of 40cm x 60cm, accommodating 16 plants in each unit. The distance kept between each experimental unit was 50 cm. During field preparation, chicken manure at the rate 7 kg per bed was applied uniformly to all the experimental units. All other agronomic practices were kept uniform with timely irrigation and weeding. For the treatment T_1 and T_2, plastic mulch with black and silver colour was used. Silver colour was laid up to reflect heat away and to regulate temperature and black colour was laid down to prevent weed growth. Paddy straw mulching was done for T_3 which was spread evenly over the bed until the soil could not be seen. EM was applied at the time of sowing to $T_1$and T_3 at the rate 40 ml per litre and subsequent EM applications were done fortnightly at the same rate until the crops were harvested. Basic research on the effect of different rate of EM application on cabbage was conducted at ARDC Samtenling and the result shows that 40ml/L was optimum for increasing the yield of cabbage. Therefore, the same rate of 40ml/L of EM was applied for beans to study its effect on Japanese pole beans.

2.3. Data collection and analysis

The harvesting commenced from 6th July and a three-time harvest was done.The beans were harvested at horticulture maturity when the pods are mature, fleshy, bright green in colour, and when the seeds are small and green, and suitable for consumption as vegetable. All border crops were rejected for the observation. Data were collected on total yield, pod length, pod diameter, pod weight and 50 percent anthesis. Data were fed to one-way analysis of variance using statistical tool STAR 2.0.1 at 5 percent level of significance.

3. Results & Discussion

3.1. Yield

From the experiment, it was observed that the highest yield per plant was obtained from$T_1$with average yield of 0.72 kg per plant followed by treatment T_3 (0.67kg per plant) but there is no statistical difference between the two treatmentswith EM application which is associated with plastic mulching and organic mulching respectively. In terms of yield per acre, similar observation was made where there is no statistical difference between the treatments T_1 (9.00 metric tonne per acre) and T_3 (9.68 metric tonne per acre). It is stated that with general use of EM, the yield is expected to increase by 20 to 30 percent and even by 50% to 100% in certain cases when applied in soil (Higa & Parr, 1999). The spray of EM (foliar application) on cabbage at the rate 1:5000 at 15 days interval was found to increase cabbage yield by 91.58% more than the control (Yadav, n.d.). In contrast, there is no significant difference in yield between treatment T_2 and T_3. Likewise, there is no significant difference between the acreage yield of treatmentT_2 and T_3. The performance of control (T_0- without mulch & without EM application) was lowest and statistically different from all other three treatments *(P-value*: 0.0017 and 0.0018). The increase in the yield is a result of the combined effect of EM application and mulching. Increase of yield in rice and maize by 4.2% and 13% respectively were reported when the EM was sprayed on the plants at the rate 20 l/ha (Lim, Pak, Jong, 1999). Javaid (2006) also found out that there is 145% increase in the grain yield of peas with foliar application of EM when supplemented with green manure crop. The conclusion was also made by Javiad and Bajwa (2011) that EM should be applied in combination with farm yard manure or recommended dose of fertilizer for better plant growth and yield in mung beans. The high yield of 644 kg/ha in sesame was noticed when mulched with Sudan grass and lowest yield from no mulch (190 kg/ha) by Teame, Tsegay, & Abrha (2017).

Table 1. Comparison of means on the yield

Treatment	Yield per plant (kg)	Yield per acre (MT/acre)
T_1- Plastic mulch with EM application	0.72a	9.68a
T_2- Plastic mulch without EM application,	0.54 b	7.29 b
T_3- Paddy straw mulch with EM application	0.67ab	9.00ab
T_0- Without mulch & without EM application (Control)	0.34 c	4.61 c
P-value	0.0018	0.0017
Treatment Mean	0.57	7.65
CV (%)	21.47	21.47

*Means in columns followed by the same letter are not significantly different

3.2. Germination percentage

EM was applied at the time of mulching before sowing and the results shows that with EM treatment, germination percentage is high with 99.0% and 97.80% in treatment T_1 and T_3 respectively. Germination percentage is also high in T_2 with 98.80% but with no significant differences among the treatments. This confirms that EM application in combination with mulching improves germination. It is observed that coffee seed germinated highest with 76. 47% when sown in forest soil and EM compost mixture at a ratio of 75:46 (Mohammed, Gebreselassie, & Nardos, 2013). In a study by Mowa and Mass (2012), seeds of *Harpagophytum procumbens* when treated with EM gave 32% germination against when treated with sulphuric acid (17%). Germination rate and percentage of mulberry seeds were observed highest in plastic mulch (0.088% and 84.60%) and dried weeds mulching (0.070% and 80.60%) by Wani et al. (2017). Zerga, Alemu, Tebasa, & Tesfaye (2017) also noticed 50% hot pepper seedling emergence in 11 days with grass mulch against 13 days with banana leave mulches. This further substantiates effect of mulching in early germination.

Table 2. Comparison of means on the germination percentage

Treatment	Germination (%)
T_1- Plastic mulch with EM application	99.20
T_2- Plastic mulch without EM application,	98.80
T_3- Paddy straw mulch with EM application	97.80
T_0- Without mulch & without EM application (Control)	96.80
P-value	0.1695
Treat mean	98.15
CV (%)	1.74

3.3. 50% anthesis and days to maturity

The number of plants reaching 50% anthesis was recorded at 36 days after sowing and data shows no significant difference among the treatments (*P- value*: 0.234) (Table 3). However, the least number of plants were observed in treatment T_3 with 11.8 plants followed by T_1 (12 plants). The number of plants reaching 50% anthesis between the treatment T_2 and T_0 is on an average 14.20. Similarly, there is no statistical difference (*P-value*: 00.97) in the days taken to maturity among the treatments. EM and mulching do not have positive effect on the days to maturity and from the data it was observed that maturity was delayed by one day as compared to the treatment without EM application. Days taken for horticultural maturity (69.34 days) in treatment T_1 is at par with the treatment T_2. Similarly, days taken for horticultural maturity are 68.14 days in both the treatment T_3 and control. The application of EM at the rate 1.5 percent has been found to significantly reduce the days to first female flower emergence (59.78%) and days to first fruit picking (67.94%) in a study by Singh, Verma, Rajnarayan, & Singh (2018). Similar observation on delayed flowering was also made by Lu et al. (2018) where rhizosphere EM increases and prolongs the availability of nitrogen. This nitrification process converts tryptophan to the phytohormone indole acetic acid (IAA) which downgrades the genes responsible for flowering.

Table 3: Comparison of means on the growth attributes

Treatment	No. of plants with 50% anthesis at 36 DAS*	Days to maturity	Pod weight (g)	Pod length (cm	Pod diameter (cm)
T_1- Plastic mulch with EM application	12.4	69.34a	15.61	20.34	0.964
T_2- Plastic mulch without EM application,	14.2	69.34a	15.44	20.14	0.948
T_3- Paddy straw mulch with EM application	11.8	68.14 b	14.76	20.4	0.948
T_0- Without mulch & without EM application (Control)	14.2	68.14 b	13.98	19.36	0.936
P-value	0.2344	0.0097	0.5928	0.2899	0.8404
Treatment mean	13.15	68.74	14.95	20.06	0.949
CV (%)	16.47	0.9201	13.67	4.51	5.14

*DAS=Days after sowing

3.4. Quality attributes of the beans

Qualitative characters such as pod weight, pod length and pod diameter were measured. Highest pod weight was recorded in the treatment T_1 with average weight of 15.61g followed by T_2, T_3 and $T_{4;}$ but with no statistical difference. Similarly, there is no significant difference in the pod length. However, average pod length was recorded highest in T_3 (organic mulch and EM application) at 20.40 cm. Likewise, highest pod diameter was recorded in treatment T_1 (0.96 cm) but there is no statistical difference. The lowest pod diameter was noticed in the treatment T_4 (no mulch and no EM application) with average diameter of 0.936cm diameter. Analyses show that there is effect of EM on the quality attributes of beans but they are not significant.

The effect of EM on the growth of onion with respect to growth parameters like plant height and fresh weight of leaves was shown by Fawzy et al, (2012) where yeast was sprayed at 3g per litre of water. The effect of EM on growth was also demonstrated by Górski & Kleiber in 2010 where foliar application of EM increased the number of inflorescence and diameter of rose and number of leaves in gerbera flowers. This is due to EM application and its mechanism of action in plants. Higa (cited in Olle & Williams, 2013) states that EM increases photosynthesis, which enhances the growth of physiological parameters. It also increases uptake of nutrients (N, P, K, Ca, Mg, Fe, Zn, and Cu) as mentioned by Talaat, Ghoniem, Abdelhamid, & Shawky (2014) which improves the growth performance of common beans. Bossuyta and Hendrix (Cited in Joshi, Somduttand, Choudhary, & Mundra, 2019) have shown that EM harnesses energy from sun and uses it to convert organic compound into amino acids, nucleic acids and sugars which in turn promote plant growth. Chantal, Xiaohou, Weimu, & Ong (2010) explain that with EM application leaf area and photosynthesis are increased in cabbage while they are reduced with application of chemical fertilizers. It is also concluded that EM treated bean plants are more efficient in photosynthesis with longer duration of two week as compared to non-treated plants (Iriti et al., 2019). Chowdhury, Islam, Hossain, & Haide (1993) also reported the increase of leaf chlorophyll in string beans with EM application. Application of EM affects the phenology and growth of the plants.

4. Conclusion

Significant effect in terms of yield of beans was due to combined effect of both mulching and EM application. EM application and mulching do not have significant effect on the quality attributes of the beans but there was positive correlation. Positive correlation is also observed in the combined effects on germination percentage with the highest in treatment with plastic mulching and EM application. This research indicates that EM application does not have significant effect on bean yields on its own. Therefore, further research on the effect of different methods and rates of EM application on the crop, and the mechanism of EM effect is required. At the same time, research is also important to study the role of EM in phenotypic changes in the growth of the crop, nutrient content and crop shelf life.

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