Journal of Dry Zone Agriculture, 2020, 6 (1): 43 - 51

ISSN 2012 – 8673

# Enhancing Storability of Ridge Gourd (*Luffa acutangula* L.) Seeds under Ambient Conditions by Reducing Seed Moisture Content using Silica Gel

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**Abstract**: The storage of vegetable seeds after harvest till next planting time assumes prime importance for successful breeding and seed production programmes since the seed viability and vigour in storage are regulated by many physico-chemical factors. Therefore, experiments were carried out to study the possibility of enhancing storability of ridge gourd (*Luffa acutangula* L.) seeds using silica gel under ambient conditions at the Department of Vegetable Science, Horticultural College and Research Institute, Coimbatore during 2017-2018 using seeds of ridge gourd variety CO1. The experimental design was Factorial Complete Randomized Block Design with four replications. Factor 1 included 3 levels of moisture content *viz.,* 9% (shade dried fresh seeds), 6% and 4% (dried using Silica gel). Factor 2 included 4 different packing materials *viz.,* Aluminum foil (polylined), polyethylene cover (500 gauge), polyethylene cover (700 gauge) and cloth bag and stored for 15 months under ambient temperature. The results showed that during "0" storage period the seeds with 6% moisture content packed in polythene cover of 500 gauge thickness recorded a higher germination percentage (74%), vigour Index I and II (3142.2 and 71 respectively). During 3 months, the Vigour Index II (49) was higher in seeds with 6% moisture content packed in polythene cover of 500 gauge thickness. During 6 months, seeds with 4 % moisture content packed in polythene cover of 500 gauge thickness recorded higher germination percentage (57%) and Vigour Index I (2111.85). During 9 months, the seeds with 4% moisture content packed in Aluminium foil registered higher germination percentage (88%) and Vigour Index II (91.68). It can be inferred that the seeds packed in aluminum foil (polylined) expressed the highest germination percentage (88%) and vigour index II (91.68) up to 9 months. Desiccated seeds stored in moisture impervious containers produced more vigourous seedlings. Thus, adoption of appropriate moisture level and packing materials would significantly increase the storability of ridge gourd seeds under ambient conditions.

***Keywords:*** Germination percentage, Ridge gourd**,** Storability, Vigour index

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## Introduction

Vegetable seeds in which moisture content is reduced to lower levels exhibited more tolerance to storage even with warm temperatures. Prolonged drying under sun will not be able reduce the moisture to the levels which are low enough for assuring the long-term seed viability. The concept of drying seeds to lower moisture levels has come into the existence to replace the compulsory requirement for cold storages as they have several constraints. Several experiments were conducted by taking different crop species to know the impro vement in the longevity of seeds which were dried on to low moisture contents (5 - 7%) for enhanced storability (Ellis *et al*., 1995). Previous studies reported that there exists certain limits along with the involved beneficial effects of such drying in which drying the seeds to below a recommended or optimum or critical moisture level are not going to improve the longevity of the seeds and in turn there is possibility of having the detrimental effects which influences the seed storability. (Nassari *et al*., 2014). Thus, before initiation of the storage of seeds at low moisture levels, there is a need to evaluate the possible benefits as well as risk of ultra-drying technology on the quality of seeds.

The areas where high humidity prevails, storage of seeds will become a challenging task. Hence, packaging materials plays a major role in extending the storability of the seeds. The moisture proof containers will inhibit the exchange of the moisture between the seeds and the surrounding atmosphere manifests in enhanced storability. Deteriorative changes like reduced seedling vigour and reduced germinability occurs when seeds are stored for long periods. Therefore, standardization of appropriate packaging material and moisture content will give the better results in the field. In the present study experiments were conducted to find out the better packaging material and moisture content to improve the storability of ridge gourd seeds.

## Materials and Methods

The study was conducted at the Department of Vegetable Science, Horticultural College and Research Institute, Coimbatore during 2017-2018. The seeds of ridge gourd variety CO1 were used for the experimental purpose.

***Treatments: Two Factors***

***Factor-1*:** Moisture content was brought down to required level by using silica gel. The moisture content of the seeds was measured using moisture meter.

1) 9% ($M_1$)
2) 6% ($M_2$)
3) 4% ($M_3$)

***Factor-2*:** Packaging material

1) Aluminium foil (Polylined) ($T_1$)
2) Polythene cover 500 guage ($T_2$)
3) Polythene cover 700 guage ($T_3$)
4) Cloth bag ($T_4$)

***Replications:* 4**
Design: Completely Randomized Block Design with two factor levels

***Duration of Storage*:**
15 months under ambient temperature

***Observations*:**
At three months intervals (0, 3, 6, 9, 12 and 15 months) the seeds from different packing materials were sown on paper towels and observations on seed growth parameters *viz.,* Germination percentage, vigour index I and vigour index II were recorded.

***Germination Percentage***
Germination percentageis an estimate of the viability of a population of seeds. The germination rate provides a measure of the time course of seed germination. The equation to calculate germination percentage is:
Germination percentage = seeds germinated/ total seeds x 100

***Seedling Length (cm)***
The seedling length was measured from the collar region to the tip of the primary leaf. The mean seedling length was expressed in centimeters.

***Seedling Dry Weight (mg)***
The selected seedlings were kept in butter paper and dried in hot air oven at $80 \pm 1^0$C temperature for 24 hours. Then seedlings were removed from oven and allowed to cool before weighing on an electronic balance. The average weight of dried seedlings from each replication was calculated and expressed as dry weight of seedling in milligrams.

***Seedling Vigour Indices***
Seedling vigour indices were calculated by using the below formula as suggested by Abdul-Baki *et al*., 1973 and expressed in whole number.

Vigour Index I = Germination (%) x Seedling length (cm)
Vigour Index II = Germination (%) x seedling dry weight (mg)

***Seed Drying Procedure***
The fresh seeds were dried under shade to bring down the moisture content to 8-10%. Using silica gel the seeds were dried to 6% and 4% moisture content. The moisture content was checked using moisture meter.

***Statistical Analysis***
The mean value of observations recorded on different seed parameters was subjected to statistical analysis. The analysis of variance for seed parameters were done by the method suggested by Panse and Sukhatme, 1967.

## Results and Discussions
In the present study different levels of moisture and packing materials were studied to have substantial information on their seed parameters. Significant differences were observed for the seed

parameters at different moisture levels and in different packing materials (Table 1).

In this experiment, the results showed that during "0" storage period the ridge gourd seeds with 6% moisture content packed in polythene cover of 500 gauge thickness recorded a higher germination percentage (74%), vigour index I (3142.2) and vigour index II (71) than when stored at 4% moisture content. (Plate 1)

During 3 months storage period, seeds with 6% moisture content packed in polythene cover of 500 gauge thickness recorded a higher germination percentage (71%), vigour index I (2595.6) and vigour index II (49).

During 6 months storage period, seeds with 4 % moisture content packed in polythene cover of 500 gauge thickness recorded higher germination percentage (57%),vigour Index I (2111.85)and vigour index II (55.78).

During 9 months storage period, the seeds with 4% moisture content packed in Aluminium foil registered higher germination percentage (88%),vigour index I (3587.40) and vigour index II (91.68). During 12 months storage period, the seeds with 6 % moisture content packed in polythene cover of 500 gauge thickness recorded higher Vigour Index II (67.83). During 15 months storage period, the seeds with 6 % moisture content packed in cloth bag registered higher germination (71%).

Kartoori Saisanthosh and Biradar Patil, (2018) concluded that higher storability of onion seeds under tropical and sub-tropical Indian conditions could be achieved when seeds are dried to the extent of 5.00 percent and sealed in aluminum pouch or polyethylene bags 700 gauge under ambient conditions.

Higher seed quality parameters were also reported in moisture vapour proof containers by previous researchers in different crop seeds (Sultana *et al*., 2016).

Generally seeds stored in moisture impervious containers like aluminum foil pouch, polythene bag (700 gauge), vacuum sealed containers etc., have storability for longer period compared to those stored in moisture pervious containers like cloth bag, paper bag, jute bag etc., under ambient storage condition. The concept of storing seeds in moisture impervious sealed containers is to prevent the migration of moisture content from the surrounding environment into the seeds. In sealed hermetic storage conditions, the seeds retain viability and vigour for longer period owing to lesser fluctuation of moisture content and tempera ture, decreased oxygen and enrichment of carbon dioxide in the containers. These findings were in conformity with the findings of Shanthappa Tirakannanavar

and Ramaiah (2006) in red gram and Basavegowda *et al.* (2013) in chickpea who reported the less fluctuation in seed moisture in the impervious packaging materials as compared to cloth bag. The seeds are hygroscopic in nature and attain equilibrium moisture content by gaining or loosing moisture content depending upon nature of containers in which they are stored.

## Conclusions

In this experiment, the results showed that higher storability of ridgegourd seeds could be achieved when seeds are dried and sealed in aluminum pouch or polyethylene bags of 500 gauge under ambient conditions. Seeds packed in aluminum foil expressed the highest germination percentage (88%) and vigour index II (91.68) up to 9 months.


## Acknowledgment

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**Table 1:** Performance of moisture levels and packaging materials on seed growth parameters

| Storage period | Moisture content | Treatment | Germination percentage | Vigour Index I | Vigour Index II |
|---|---|---|---|---|---|
| 0 months | 9%($M_1$) | $T_1$ | 55 | 2146.1 | 47.08 |
| | | $T_2$ | 56 | 2206.9 | 43.93 |
| | | $T_3$ | 55 | 2149.0 | 43.35 |
| | | $T_4$ | 72 | 2935.6 | 65.49 |
| | 6%($M_2$) | $T_1$ | 51 | 1951.2 | 40.55 |
| | | $T_2$ | 74 | 3142.2 | 71.13 |
| | | $T_3$ | 62 | 2663.0 | 61.10 |
| | | $T_4$ | 51 | 2146.9 | 45.37 |
| | 4%($M_3$) | $T_1$ | 56 | 2175.9 | 44.38 |
| | | $T_2$ | 48 | 1962.2 | 36.02 |
| | | $T_3$ | 48 | 1876.6 | 42.23 |
| | | $T_4$ | 67 | 2560.2 | 63.43 |
| CD (0.05) | | M | 0.61 | 4.31 | 0.82 |
| | | T | 1.75 | 7.22 | 2.77 |
| | | M x T | 5.02 | 10.01 | 5.03 |
| 3 months | 9%($M_1$) | $T_1$ | 62 | 2235.00 | 35.23 |
| | | $T_2$ | 54 | 1972.08 | 37.99 |
| | | $T_3$ | 55 | 2037.94 | 38.27 |
| | | $T_4$ | 50 | 1756.42 | 30.42 |
| | 6%($M_2$) | $T_1$ | 66 | 2373.78 | 41.45 |
| | | $T_2$ | 71 | 2595.60 | 49.00 |
| | | $T_3$ | 61 | 2199.04 | 41.59 |
| | | $T_4$ | 59 | 2193.53 | 39.54 |
| | 4%($M_3$) | $T_1$ | 71 | 2599.83 | 40.13 |
| | | $T_2$ | 60 | 2182.66 | 42.68 |
| | | $T_3$ | 71 | 2572.39 | 44.95 |
| | | $T_4$ | 62 | 2294.76 | 39.40 |
| CD (0.05) | | M | 0.61 | 4.01 | 0.74 |
| | | T | 1.12 | 7.32 | 2.02 |
| | | M x T | 4.91 | 9.87 | 6.12 |
| 6months | 9%($M_1$) | $T_1$ | 55 | 2062.17 | 52.79 |
| | | $T_2$ | 50 | 1809.95 | 26.80 |
| | | $T_3$ | 61 | 2302.51 | 47.04 |
| | | $T_4$ | 65 | 2618.34 | 64.15 |

| | | | | | |
|---|---|---|---|---|---|
| | 6%($M_2$ | $T_1$ | 50 | 1774.15 | 51.34 |
| | | $T_2$ | 56 | 1934.40 | 46.44 |
| | | $T_3$ | 43 | 1530.64 | 33.38 |
| | | T | 57 | 2045.36 | 42.61 |
| | 4%($M_3$ | $T_1$ | 48 | 1739.83 | 28.77 |
| | | $T_2$ | 57 | 2111.85 | 45.78 |
| | | $T_3$ | 51 | 1827.12 | 43.09 |
| | | $T_4$ | 57 | 1935.55 | 51.49 |
| CD (0.05) | | M | 5.88 | 263.10 | 8.31 |
| | | T | 6.79 | 303.79 | 9.59 |
| | | M x T | 11.76 | 526.20 | 16.62 |
| 9months | | $T_1$ | 83.0 | 3140.80 | 39.40 |
| | 9%($M_1$ | $T_2$ | 88.0 | 3054.40 | 11.60 |
| | | $T_3$ | 82.5 | 3212.40 | 64.54 |
| | | $T_4$ | 83.0 | 3153.32 | 45.93 |
| | 6%($M_2$ | $T_1$ | 82.5 | 3050.19 | 46.24 |
| | | $T_2$ | 85.0 | 3351.30 | 45.12 |
| | | $T_3$ | 75.0 | 2385.48 | 38.78 |
| | | $T_4$ | 84.5 | 3068.09 | 39.59 |
| | 4%($M_3$ | $T_1$ | 88.0 | 3587.40 | 91.68 |
| | | $T_2$ | 84.0 | 3237.05 | 66.88 |
| | | $T_3$ | 78.0 | 2811.67 | 56.75 |
| | | $T_4$ | 87.0 | 3758.16 | 16.29 |
| CD (0.05) | | M | 11.28 | 502.24 | 2.00 |
| | | T | 13.02 | 579.9 | 3.00 |
| | | M x T | 22.55 | 1004.4 | 6.00 |
| 12months | | $T_1$ | 66 | 2152.65 | 35.46 |
| | 9%($M_1$ | $T_2$ | 62 | 2144.10 | 51.16 |
| | | $T_3$ | 70 | 2429.60 | 48.59 |
| | | $T_4$ | 59 | 1813.06 | 43.42 |
| | 6%($M_2$ | $T_1$ | 59 | 1942.77 | 46.05 |
| | | $T_2$ | 67 | 2239.68 | 67.83 |
| | | $T_3$ | 75 | 2686.07 | 64.78 |
| | | $T_4$ | 58 | 2223.94 | 43.33 |
| | 4%($M_3$ | $T_1$ | 75 | 2276.33 | 46.68 |
| | | $T_2$ | 61 | 1972.70 | 47.81 |
| | | $T_3$ | 62 | 1983.89 | 46.76 |
| | | $T_4$ | 57 | 1552.95 | 40.72 |
| CD (0.05) | | M | 8.61 | 58.30 | 8.82 |

| | | | | | |
|---|---|---|---|---|---|
| | | T | 9.94 | 67.32 | 10.18 |
| | | M x T | 17.21 | 116.60 | 17.63 |
| | | $T_1$ | 52 | 2194.03 | 38.55 |
| | 9%($M_1$) | $T_2$ | 54 | 1893.36 | 29.68 |
| | | $T_3$ | 58 | 2311.62 | 44.52 |
| | | $T_4$ | 64 | 1564.33 | 14.99 |
| | | $T_1$ | 58 | 1833.20 | 52.66 |
| | | $T_2$ | 64 | 2105.14 | 54.4 |
| 15months | 6%($M_2$) | $T_3$ | 60 | 1814.02 | 49.09 |
| | | $T_4$ | 71 | 2254.66 | 40.52 |
| | | $T_1$ | 62 | 2276.90 | 28.16 |
| | | $T_2$ | 50 | 1943.86 | 36.49 |
| | 4%($M_3$) | $T_3$ | 58 | 1922.01 | 53.33 |
| | | $T_4$ | 54 | 2228.98 | 30.42 |
| CD (0.05) | | M | 51.42 | 114.33 | 126.2 |
| | | T | 59.37 | 132.02 | 145.73 |
| | | M x T | 102.84 | 228.66 | 252.41 |

M - Moisture content

T - Treatment

MxT - Interaction effect of Moisture content and Treatment

CD – Critical Difference

CV – Coefficient of variation

Sultana, R., Chowdhury, M.S.M., Islam, M.R. and Akhter, K. 2016. Effect of container and duration of storage on the quality of okra (*Abelmoschus esculentus*) seeds. The Agriculturists. 14 (1):63-72.

0m: 6% Polycover 500gauge G %( 74)
VI 1 (3142.2)
VI2 (71)

3m: 6% Polycover 500gauge G %( 71)
VI 1 (2595.6) VI 2 (49)

6m: 4% Polycover 500gauge
G %(57)
VI 1 (2111.85) VI 2 (55.78)

9m: 4% Aluminium foil
G%(88)
VI 1 (3587.4) VI 2 (91.68)

**Plate 1:** Performance of moisture levels and packaging materials on seed growth parameters

Journal of Dry Zone Agriculture, 2020, 6 (1): 52 - 62

ISSN 2012 – 8673

# Effect of Spacing and Application of Foliar Nutrients on Growth and Yield of Black Pepper (*Piper nigrum*)

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**Abstract:** An experiment was conducted at Horticultural Research Station, Pechiparai, Tamil Nadu, India during 2014 - 2017. The objective of the study was to find out the effect of different spacing and foliar nutrients on the growth and yield of black pepper. The variety Panniyur-1 (Bush type) was selected for the study. The soil of the experimental area is red laterite and this experiment was laid out in Factorial Randomized Block Design with three replicates. Pepper is a vine trained in support trees grown at a spacing of 3 X 3 m. In this study three closer spacing's ($S_1$ - 2.0 x 2.0 m , $S_2$ - 1.5 x 1.5 m, $S_3$ - 1.0 x 1.0 m ) and the foliar nutrients ($F_1$-Humic acid @ 0.2%, $F_2$ – Panchagavya @ 3.0%, $F_3$-NPK 19:19:19 spray @ 0.2%, $F_4$-GA3 spray @ 20ppm and $F_5$ – Control -Water spray) were used as treatment combinations. Soil application of 1.0: 0.5: 2.0 g of NPK per plant at bi monthly intervals were applied uniformly to all plants as per the recommended package of practices of Tamil Nadu. The foliar nutrients as per the treatment specification were imposed for achieving a rapid response and were given in fortnightly intervals commencing from third month after planting. Observations were recorded on the height of the bushes at the time of harvest, number of spikes/bush, spike length, number of berries/spike. The green berry yield was also recorded. Among the different treatments $S_1F_3$ (spacing 2.0 x 2.0 m and NPK 19:19:19 spray @0.2%) recorded the highest number of spikes per vine (143.10), spike length (16.24 cm) and the highest green berry yield of 1.1 kg/bush and it was significantly superior over the other treatment combinations.

***Keywords:*** Bush black pepper, Foliar application, Panniyur – 1, Spacing,Tamil Nadu, India

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## Introduction

Black pepper (*Piper nigrum),*the black gold of spices is one of the most popular spice in the world. India had a monopoly in world black pepper production in 1950's and till 2002 India was the largest producer. At present Vietnam top the list accounting to 38.6 % share of global production and India ranks the second. The productivity of pepper in Vietnam is 2.0 tonnes per hectare. In Thailand the productivity is 4.3 tons per hectare. But the productivity in India is only 0. 275 ton/ha/year.India is one of the largest consumers of black pepper. Besides Indian origin pepper is considered to be of best quality and attract importers. As India's pepper production has been declining rapidly there is a need to scale up the pepper productivity.

In pepper harvesting is a problem as it is trained in tall trees for support. Harvesting the spikes at greater heights involve skilled labourers. It is a time consuming operation and should be completed in a stipulated time and if harvested in over ripened stage the quality of the produce will be deteriorated. The harvesting season is from November to February in plains and January to March in the hills. As this operation is seasonal, severe labourer shortage arises during these periods. So there is a need for lowering the height of pepper so that it minimize the drudgery in pepper harvest and ensure quality pepper production as the harvesting can be taken up at the correct stage.

Bush pepper needs no standards for trailing or climbers for harvesting. They start flowering from the same year (Ravindran, 2003). They also continue to flower in all seasons of the year if adequate watering and manuring are done. Thus, pepper will be available in all the year round. So far it is grown as a potted plant with decorative and economic value especially by the urban/flat dwellers to taste field fresh spices. Also, the reported results of research on foliar nutrition of bush peppers are scarce and concerned mainly with soil application of nutrients. Many earlier workers in the field of black pepper nutrition has reported that production and productivity of pepper in India can be increased considerably through an integrated approach in which nutrition can play a major role (Pillai *et al.,* 1979 and Sadanandan, 1992). With this in view the following experiment was undertaken with the main objective to exploit the maximum productivity from bush pepper.

## Materials and Methods

The field experiment was conducted at the main farm of Horticultural Research Station, Pechiparai, Tamil Nadu during 2014 to 2017. The field is located at 8˚26' North latitude, 77˚ 19' East longitude with in altitude of 76 m above mean sea level (Plate 1). The mean annual rainfall during the experimental period was 2210 mm. The mean maximum and minimum temperatures were 32.6 and 25.8 ˚C, respectively for three consecutive years.

**Plate 1**: Experimental Field view

The mean relative humidity is 83.0%. The soil of the experimental area is red laterite and acidic in texture and this experiment was laid out in Factorial Randomized Block Design with three replicates. The details of the treatments are as follows. The spacing (S)treatments are $S_1$-2.0x2.0 m , $S_2$-1.5x1.5 m, $S_3$-1.0x1.0 m and the foliar nutrition (F) treatments are $F_1$-Humic acid @ 0.2%, $F_2$ – Panchagavya @ 3.0%, $F_3$-NPK 19:19:19 spray @ 0.2%, $F_4$-GA3 spray @ 20 ppm and $F_5$ – Control (Water spray).

The land was ploughed thoroughly and brought to fine tilth. Pits were dug at appropriate spacing's for each treatment and 5 kg of Farm yard manure is mixed with the top soil and the pits were filled. The rooted cuttings developed from plagiotropic shoots of Panniyur -1 pepper were planted. Planting was taken up during June 2014. The plants were maintained with soil application of 15 and 33 g of ground nut and neem cake, respectively and 1: 0.5:2 g of NPK /pit at bi monthly intervals as per the recommendations given by crop production manual of Tamil Nadu . Irrigation was given as and when necessary based on the soil moisture. The foliar spraying of nutrients were taken up at fortnightly intervals commencing from third month after planting as per the treatment specifications. As the plants were developed from plagiotropic shoots it was having a bush like canopy instead of vine (Plate 2).

**Plate 2**: Bush Black Pepper

The harvest of the spikes was taken up during the month of December 2015, 2016 and 2017. An interim harvest was also taken up during June 2016 and 2017. In each treatment combination five plants were selected at random and observations were recorded. Observations were recorded on the height of the bushes and number of spikes/bush. The spikes were harvested and the individual spike length, number of berries/spike and green berry yield were recorded. The recorded observations were subjected to statistical analysis as per ANOVA and the results are presented below.

## Results and Discussion

There were significant differences among the various treatment combinations for different traits. The highest plant height (0.67 m) was obtained in the treatment $S_3F_3$ (1.0x1.0m spacing and foliar spraying of NPK 19:19:19 spray @ 0.2%) followed by $S_2F_3$ (1.5 x1.5 m spacing and foliar spraying of NPK 19:19:19 spray @ 0.2%) which was 0.63 m. $S_1F_5$ (2.0 x 2.0m spacing and water spray) had recorded the least plant height of 0.42 m (Table 1). This may due to the fact that continuous maintenance of high levels of nutrients in the plant is indispensable for the profitable land use and sustainable production of pepper (Sadanandan, 1993). Black pepper needs replenishment of nutrients if it requires continuous harvest (Waard, 1964). In this experiment also the highest plant height was due to the foliar application of 0.2%spray NPK @ 19:19:19 as the crop is highly responsive to nutrients. Besides as sprays were given

**Table 1:** Effect of spacing and foliar nutrients on plant height and number of branches at harvesting stage

| | **Plant height (m)** | | | **No of branches per plant (Nos)** | | |
|---|---|---|---|---|---|---|
| | **Spacing(m)** | | | **Spacing(m)** | | |
| | **2.0 x2.0** | **1.5x1.5** | **1.0x1.0** | **2.0 x2.0** | **1.5x1.5** | **1.0x1.0** |
| | **$S_1$** | **$S_2$** | **$S_3$** | **$S_1$** | **$S_2$** | **$S_3$** |
| Humic acid @0.2%, $F_1$ | 0.47 | 0.52 | 0.54 | 26.45 | 26.43 | 26.38 |
| Panchagavya@3.0 %, $F_2$ | 0.55 | 0.57 | 0.59 | 29.38 | 29.37 | 29.33 |
| NPK 19:19:19 spray @ 0.2%, $F_3$ | 0.60 | 0.63 | **0.67** | **32.54** | 32.52 | 32.47 |
| GA3 spray @20 ppm, $F_4$ | 0.51 | 0.54 | 0.55 | 29.48 | 29.43 | 29.36 |
| Control (Water spray), $F_5$ | 0.42 | 0.46 | 0.49 | 25.24 | 25.18 | 25.13 |
| Mean | 0.51 | 0.54 | 0.57 | 28.62 | 28.57 | 28.54 |
| | S | F | S x F | S | F | S x F |
| S.Ed | 0.013 | 0.015 | 0.027 | 1.05 | 1.23 | 1.59 |
| CD (0.05) | 0.038 | 0.031 | 0.065 | 2.25 | 2.61 | 3.04 |

**Table 2:** Effect of spacing's and foliar nutrients on number of spikes per bush and spike length

| Foliar sprays | **Number of spikes per bush (No)** | | | **spike length (cm)** | | |
|---|---|---|---|---|---|---|
| | Spacing(m) | | | Spacing(m) | | |
| | 2.0 x2.0 $S_1$ | 1.5x1.5 $S_2$ | 1.0x1.0 $S_3$ | 2.0 x2.0 $S_1$ | 1.5x1.5 $S_2$ | 1.0x1.0 $S_3$ |
| Humic acid @0.2 per cent, $F_1$ | 84.24 | 79.60 | 75.44 | 11.67 | 11.22 | 10.78 |
| Panchagavya@3.0 percent, $F_2$ | 95.82 | 90.20 | 88.17 | 12.85 | 12.68 | 11.44 |
| NPK 19:19:19 spray @ 0.2%, $F_3$ | **143.10** | 101.35 | 98.38 | **16.24** | 14.54 | 13.21 |
| GA3 spray @20 ppm, $F_4$ | 94.61 | 89.43 | 86.10 | 12.68 | 11.82 | 11.00 |
| Control (Water spray), $F_5$ | 75.20 | 68.50 | 64.40 | 10.55 | 9.45 | 9.03 |
| Mean | 98.60 | 85.82 | 82.50 | 12.80 | 11.94 | 11.09 |
| | S | F | S x F | S | F | S x F |
| S.Ed | 2.45 | 1.02 | 1.59 | 0.22 | 1.02 | 1.59 |
| CD (0.05) | 5.24 | 2.10 | 3.25 | 0.61 | 2.10 | 3.11 |

at fortnightly intervals there was a continuous supply of nutrients to the plant. The similar findings were reported by Divya Seetaram, Bhat *et al.,* 2018 in an experiment with black pepper varieties IISR-Shakti, IISR-Thevam and Panniyur-1.

The pH of the soil also plays a major role in determining the black pepper yield. The pH influences the nutrient availability. The nutrient availability will be the highest in pH between 5.5 and 6.5. This was reported by an earlier worker (Sadanandan, 1993) who has recorded that the nutrient availability in pepper growing soil is highest between pH 5.5 and 6.5 where in iron and aluminium are more soluble. In the present experiment the field had a pH of 5.7 which fell in this range and achieved maximum nutrient uptake.

Yap Chin Ann (2016) concluded that the application of foliar fertilizer supplement at the rate of 5 ml per litre of water cut down 50 % of recommended soil NPK fertilizer and was the best nutrient schedule for the black pepper variety Semongok Aman in Malaysia. In this study also the soil application of 15 and 33 g of ground nut and neem cake respectively and 1: 0.5:2 g of NPK /pit at bi monthly intervals followed by NPK 19:19:19 spray @ 0.2% recorded the longest spike (16.24cm). The highest berry yield per bush (1.1 Kg) was also recorded by the same treatment $S_1F_3$ (2.0x2.0 m spacing and foliar spraying of NPK 19:19:19 spray @ 0.2 %) (Figure 1). So, it is confirmed that pepper responds well to nutrient application especially foliar applications and is similar to the reports of Koshi *et al.* 1961.

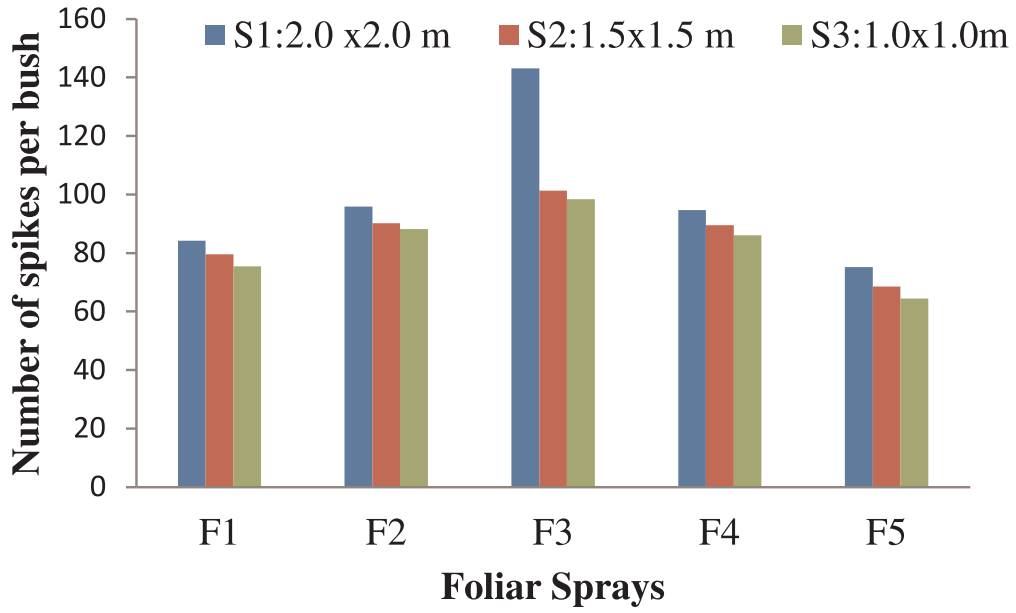


**Figure 1:** Number of spikes per bush

**Table 3 :** Effect of spacing's and foliar nutrients on number of berries per spike and green berry yield per vine

| Foliar sprays | **Number of berries per spike (No)** | | | **Green berry yield per vine (kg)** | | |
|---|---|---|---|---|---|---|
| | Spacing(m) | | | Spacing(m) | | |
| | 2.0 x2.0 | 1.5x1.5 | 1.0x1.0 | 2.0 x2.0 | 1.5x1.5 | 1.0x1.0 |
| | $S_1$ | $S_2$ | $S_3$ | $S_1$ | $S_2$ | $S_3$ |
| Humic acid @0.2 per cent, $F_1$ | 72.75 | 68.54 | 53.06 | 0.734 | 0.668 | 0.651 |
| Panchagavya@3.0 percent, $F_2$ | 79.55 | 74.98 | 72.35 | 0.882 | 0.842 | 0.811 |
| NPK 19:19:19 spray @ 0.2%, $F_3$ | **84.58** | 78.55 | 73.93 | **1.100** | 1.001 | 0.989 |
| GA3 spray @20 ppm, $F_4$ | 81.25 | 72.39 | 70.64 | 0.842 | 0.812 | 0.832 |
| Control (Water spray), $F_5$ | 70.15 | 64.55 | 49.91 | 0.619 | 0.495 | 0.447 |
| Mean | 77.66 | 71.80 | 63.98 | 0.835 | 0.764 | 0.746 |
| | S | F | S x F | S | F | SxF |
| S.Ed | 1.18 | 1.01 | 1.96 | 0.05 | 0.03 | 0.05 |
| CD (0.05) | 3.28 | 2.07 | 4.03 | 0.105 | 0.063 | 0.107 |

Pepper vines grown on living standards gave lower yields compared to those which had non –living standards as support (Figure 2). This obviously was due to competitive absorption of nutrients from the soil by living standards. This was reported in earlier periods by Menon *et al*., 1982. In this study as no standards were involved the competition for nutrients does not arise. Developing pepper from plagiotropic shoots results in bushes which does not require any standards. So the competition of nutrients by the standards does not arise in this context.

Wahid (1987), studied the seasonal variation in foliar nutrient concentration and reported that the concentration of N and K increased up to June and then decreased. With the application of NPK fertilizers in August- September the leaf concentration again increased. Among the nutrients utilized by pepper, maximum absorbed nutrients were N, K, Ca and Mg. In this experiment foliar application was given which resulted in increased concentration of N in leaves which resulted in yield increase.

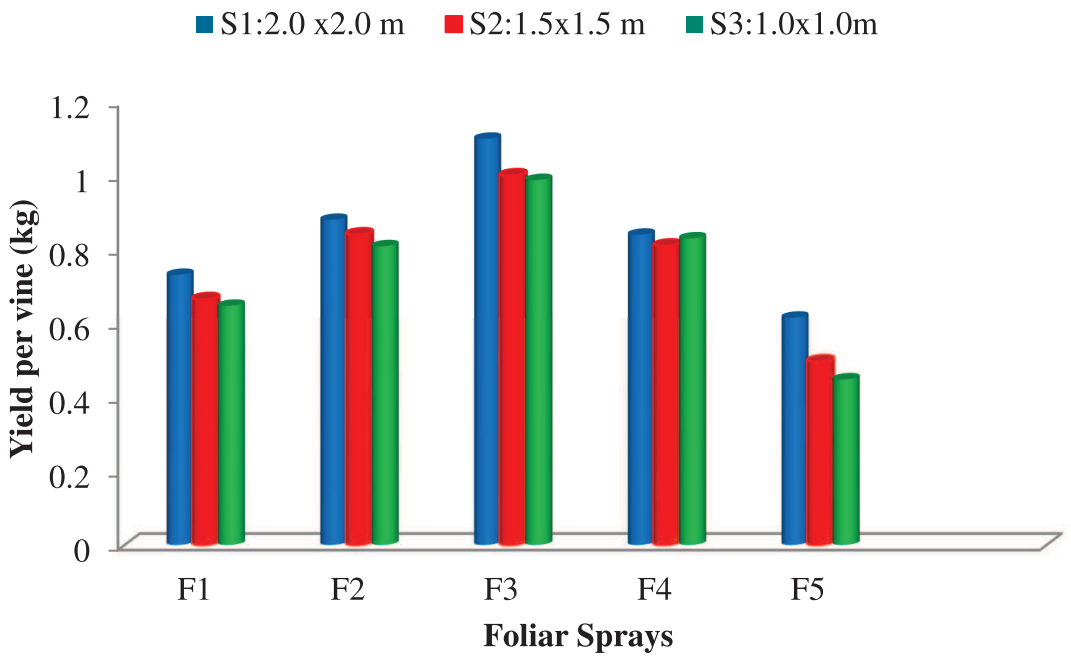


**Figure 2:** Yield per vine (kg)

However, Pillai *et al*. (1976) in an experiment to study the response of Panniyur- 1 variety of pepper to the application of nitrogen and lime pointed out that higher levels of N adversely affected the yield. According to them, it is not necessary to increase N dose to Panniyur – 1 pepper beyond certain specific level. This necessitates the standardization of optimum level of nutrients for pepper.

Further, leaving the right amount of space between the plants is quite important as each plant need certain amount of room for their roots and leaves to maximise growth. If optimum spacing is provided then the plants will perform well. Provision of optimum spacing will facilitate maximum utilisation of land and water resources. Keeping this in view, the two parameters spacing and foliar nutrients were standardised in this experiment. Accordingly, this experiment has proven that the optimum spacing and nutrients for foliar application in pepper is 2.0 x 2.0 m spacing and foliar spraying of NPK 19:19:19 spray @ 0.2% at fortnightly intervals.

A number of factors like growth stages, nutrient requirement, soil moisture conditions, nature of the fertilizer, etc., should be taken into consideration before standardising the optimum spacing and nutrient spray. The nutrients should be applied well before requirement to obtain maximum effect. Better utilization of applied nitrogen is affected by supplying it at a time when the crop need. Foliar application is more effective. As very small quantities of nutrient elements are required when compared to soil application it is more effective and economical. As the pepper plants produced from plagiotropic shoots are maintained as bushes the canopy management, foliar application of nutrients and harvesting can be easily done. As no standards are required the cost of cultivation will be less as well as this technology can be promoted for intercropping black pepper in coconut gardens.

In bush black pepper the growth is a continuous phenomenon as every new shoot ends in flowering and spike setting. Immediately a harvest is completed new sprouts initiate and further growth continues. So continuous supply of nutrients is absolutely essential. The findings of this study *viz*., 2.0 x 2.0 m spacing and foliar spraying of NPK 19:19:19 spray @ 0.2% is best for yield intensification of bush pepper. The productivity will be enhanced and year round production of pepper can be facilitated

## Conclusion

The study was undertaken to intensify the productivity of black pepper by increasing the plant population per unit area through closer spacing and managing the nutrient requirement through the additional supplementation of nutrients by foliar sprays. The variety Panniyur-1 was selected for the study. Three spacing's

($S_1$- 2.0 x 2.0 m, $S_2$- 1.5 x 1.5 m, $S_3$- 1.0 x 1.0 m) and the foliar nutrients ($F_1$-Humic acid @ 0.2%, $F_2$ – Panchagavya @ 3.0%, $F_3$-NPK 19:19:19 spray @ 0.2%, $F_4$-GA3 spray @ 20ppm and $F_5$ – Control -Water spray) were given in fortnightly intervals commencing from third month after planting. Soil application of 1.0: 0.5: 2.0 g of NPK per plant at bi monthly intervals was applied uniformly to all the plants as per the recommended package of practices. Among the different treatments the spacing of 2.0 x 2.0 m and NPK 19:19:19 spray @ 0.2%) recorded the highest number of spikes per plant (143.10), Spike length (16.24 cm) and the highest green berry yield of 1.100 kg/ bush and it was significantly superior over other treatments.

## Acknowledgement

This research work was undertaken with the technical and financial support of Tamil Nadu Agricultural University, Coimbatore and it is acknowledged with gratitude.

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