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Effect of Safed musli + pigeonpea intercropping system on yield and N, P, K status availability in soil

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Abstract
A field experiment was carried out at Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) to study the yield potential of Safed musli and N, P and K availability in soil by adopting intercropping systems during kharif season of 2015-16 and 2016-17. The experiment was laid in Randomized Block Design with four replications and six treatments. The experiment was under Safed musli + Pigeonpea intercropping with various row proportions T_1 – Safed musli + Pigeonpea 2:1 row proportion, T_2 – Safed musli + Pigeonpea 3:1 row proportion, T_3 – Safed musli + Pigeonpea 2:2 row proportion, T_4 – Safed musli + Pigeonpea 1:2 row proportion, T_5 – Sole Safed musli, T_6 – Sole Pigeonpea.
In yield contributing characters of Safed musli significantly highest number of root per plant, root length and root girth of Safed musli was increased in treatment (T_2) Safed musli + Pigeonpea 3:1 intercropping. Similarly fresh and dry root yield g plant^{-1} was significantly increased under treatment (T_2) Safed musli + Pigeonpea in 3:1 intercropping. The major nutrient (N, P and K) availability by Safed musli in soil was significantly increased under (T_4) Safed musli + Pigeonpea in 1:2 intercropping.

Keywords: Safed musli + pigeonpea, row proportion

Introduction
The concept of intercropping is to increasing total productivity per unit area and time, as well as equitable and judicious utilization of land resources and inputs. One of the main reasons for getting higher yields from intercropping systems are mainly due to the component crops are able to use face natural resources than grown separately (Willey, 1979) [14]. A careful selection of crops having different growth habits can reduce the mutual competition to a considerable extent. Hence, choice of component crops in intercropping needs to be suitably maneuvered to harvest the synergism among them towards efficient utilization of resource base and to increase overall productivity (Mandal, 1986) [8].
Chlorophytum borivilianum is a perennial important herb known as 'Safed musli' which is a root crop belonging to the family Liliaceae. The roots of *Chlorophytum borivilianum* have great medicinal value due to saponin content and used extensively in Ayurvedic medicines. The economic part of the herb is root and is well known tonic and aphrodisiac drug given to cure general debility. Tribals in central India use leaves of this herb for vegetable purpose. The species of *Chlorophytum borivilianum* contains more saponin and good yielding potentials as compared to other species of Safed musli and therefore having commercial value. Due to its vast demand it is very costly and become a hot cake among medicinal plants.
Pigeonpea is an important legume food and drought tolerant crop and having potential to sustain productivity and profitability in drought prone areas. Being a legume, the residual nitrogen available to subsequent crop is estimated to around 40 kg ha^{-1}. Intercropping with Pigeonpea provides an opportunity to grow them together as they have different growth habits and maturity period. The Pigeonpea being deep rooted and comparatively slow growing in its early growth stage, during which the more rapidly growing crops like Safed musli can be conveniently intercropped to utilize natural resources more efficiently. The sole cropping of Safed musli has a risk. The replacement of traditional crops with alternative crops like Safed musli may be unsustainable in large context and therefore it is necessary to explore the possibilities of the growing these crops as an intercrop with the traditional crop in efficient cropping systems.

Intercropping, through more effective use of water, nutrients and solar energy, can significantly enhance crop productivity compared to the growth of sole crops. Intercropping is getting greater emphasis because of yield stability and returns per unit area even under adverse condition. This system uses resources efficiently and productivity is increased. The intercropping system under medium to heavy soil is suitable under rainfed condition of Vidarbha region than sole cropping. In order to generate useful information for such type of potential areas, present investigations to study the yield potential of Safed musli and availability of nutrients in soil after harvest of crop by adopting intercropping system was proposed.

Material and Methods

The field experiment was conducted at Nagarjun medicinal plant Garden Dr. PDKV Akola during kharif season 2015-2016 and 2016-2017. Experiment was laid in Randomized Block Design with four replications and six treatments.

The experiment was under Safed musli+ Pigeonpea intercropping with various row proportions T_1 –Safed musli + Pigeonpea 2:1 row proportion, T_2 –Safed musli+ Pigeonpea 3:1 row proportion, T_3 – Safed musli + Pigeonpea 2:2 row proportion, T_4 – Safed musli + Pigeonpea 1:2 row proportion, T_5 – Sole Safed musli, T_6 – Sole Pigeonpea.

The experimental soil order was Inceptisol, the fertility status of soil was moderate in organic carbon, low in available nitrogen and available phosphorus and very high in available potassium while the soil micronutrient contents (Fe, Mn, Zn and Cu) were above the critical level. FYM @ 20 t ha^{-1} was applied common for all treatments of Safed musli and for Pigeonpea: FYM @ equivalent to RDF (25 kg N ha^{-1}).

Results and Discussion

Yield contributing characters

Number of Roots

On persual of data presented in Table 1, revealed that the number of roots per plant was significantly influenced by the intercropping in both the year. Number of roots per plant of Safed musli were ranged from 7.75 to 9.25 $plant^{-1}$ and 7.80 to 10.20 roots $plant^{-1}$ during 2015-16 and 2016-17, respectively.

From table, it was revealed that the highest no of roots of Safed musli (9.25 $plant^{-1}$) was recorded with Safed musli + Pigeonpea in 3:1 row proportion (T_2) which was at par with treatments T_3 (2:2 row proportion) and T_5 (sole Safed musli) during first year.

However, during second year (2016-17) data showed that highest number of roots (10.20 $plant^{-1}$) was recorded under Safed musli + Pigeonpea in 3:1 row proportion which at par with treatment T_5 (sole Safed musli).

Pooled data indicated that the application of Safed musli+ Pigeonpea in 3:1 row proportion (T_2) recorded significantly highest number of roots (9.70 $plant^{-1}$) followed by sole Safed musli (T_5). These results are in close agreement with Wankhade *et al.,* (2004) [13] and Anonymous (2015) [1].

Root Length

On persual of data presented in Table 1, revealed that the root length was significantly influenced by the intercropping in both the year.Root length varied from 6.35 to 7.00 cm and 6.39 to 7.24 cm during 2015-16 and 2016-17 respectively.

From table, it was observed that highest root length of Safed musli (7.00 cm) was recorded under Safed musli + Pigeonpea in 3:1 row proportion (T_2) which was at par with T_3 (2:2 row proportion) and T_4 (1:2 row proportion) during first year. However, during second year (2016-17) data showed that highest root length (7.24 cm) was recorded under Safed musli + Pigeonpea in 3:1 row proportion (T_2) while lowest (6.39 cm) root length was observed in treatment under Safed musli + Pigeonpea in 2:2 row proportion (T_3).

The pooled data indicated that the root length was significantly highest (7.12 cm^2) with treatment T_2 (3:1 row proportion) as compared to T_1 (2:1 row proportion), T_3 (2:2 row proportion) and T_5 (sole Safed musli), however, at par with T_4 (1:2 row proportion). Findings are in close accordance with the result reported by Wankhade *et al*. (2004) [13], Shivankar *et al*. (2015) [10] and Anonymous (2015) [1].

Root Girth

On persual of data presented in Table 1, revealed that the root girth was significantly influenced by the intercropping in both the year. Root girth varied from 5.38 to 6.10 mm and 5.44 to 6.05 mm during 2015-16 and 2016-17 respectively.

From table, it was observed that highest root girth of Safed musli (6.10 mm) was recorded under sole Safed musli (T_5) which was at par with treatment T_1 (2:1 row proportion), T_2 (3:1 row proportion) and T_4 (1:2 row proportion) during first year study except T_3 (2:2 row proportion). However, during second year data indicated that highest root girth (6.05 mm) recorded under of Safed musli + Pigeonpea in 3:1 row proportion (T_2) which was also at par with treatments T_5 (sole Safed musli) and T_1 (2:1 row proportion).

Pooled data indicated that the row proportion of Safed musli + Pigeonpea in 3:1 row proportion (T_2) recorded highest root girth (6.00 mm), however at par with rest of the treatments except T_3 (2:2 row proportion).

As the Safed musli is partial shade loving plant the intercropping of with Pigeonpea might have beneficial effect on Safed musli crop growth which ultimately recorded in improvement of yield contributing characters. These results are in conformity of findings of studies on Safed musli + Pigeonpea intercropping conducted at Akola Anonymous (2015) [1] and Shivankar, (2015) [10].

Safed musli fresh root yield (q $ha^{-1)}$

On persual of data presented in Table 2, revealed that the fresh root yield (q $ha^{-1)}$ significantly influenced by different intercropping proportion, From table, it was revealed that, the higher fresh root yield (33.40 q ha^{-1}) was obtained with the intercropping of Safed musli + Pigeonpea intercropping in 3:1 row proportion which was at par with treatment T_5 (sole Safed musli). While, the lowest fresh root yield (13.31 q ha^{-1}) was recorded with of Safed musli + Pigeonpea in 1:2 proportion (T_4).

During second year, the highest fresh root yield (30.44 q ha^{-1}) was recorded in T_2 (Safed musli + Pigeonpea in 3:1 row proportion) which at par with T_5 (sole Safed musli). Whereas, lowest fresh root yield (12.38 q ha^{-1}) was recorded in treatment T_4 *i.e.,* Safed musli + Pigeonpea in 1:2 proportion. Pooled data also indicated that highest fresh yield with T_2 (31.92 q ha^{-1}) followed by treatment T_5 (31.18 q ha^{-1}). Findings are in close accordance with the result reported by Wankhade *et al*. (2004) [13], Shivankar *et al*. (2015) [10] and Anonymous (2015) [1].

Safed musli dry root yield (q $ha^{-1)}$

On persual of data presented in Table 2, revealed that the dry root yield per hectare was influenced by intercropping with various row proportion of Safed musli + Pigeonpea. The dry root yield q. ha^{-1} was also significantly higher (5.67 q ha^{-1})

under treatment T_2*i.e.,* in 3:1 row proportion. In second year, significantly highest dry yield (5.17 q ha^{-1}) was recorded in T_2*i.e.,* Safed musli + Pigeonpea in 3:1 row proportion. While, lowest (2.26 q ha^{-1}) dry yield per hector was recorded in treatment T_4 under 1:2 row proportion. Pooled data indicated that significantly higher (5.42 q ha^{-1}) dry yield was recorded in treatment T_2 followed by treatment T_5 (5.30 q ha^{-1}).

The lowest fresh and dry root yield was recorded under treatment T_4*i.e.* Safed musli + Pigeonpea in 1:2 row proportion. Significantly highest root yield obtained with the intercropping of Safed musli + pigeon pea in 3:1 row might be due to favorable partial shade effect which recorded in better crop growth and ultimately the root yield. These results are supported by the findings of Wankhade *et al*. (2004) [13], who has recorded higher yield of Safed musli with the application of FYM 20 tons with various nitrogen levels.

Dry matter accumulation

On persual of data presented in Table 3, revealed that the dry matter accumulation of Safed musli (g $plant^{-1}$ and kg ha^{-1}) was ranged from 0.86 to 1.32 and 0.80 to 1.30 g $plant^{-1}$ during year 2015-16 and 2016-17 respectively.

From table, it was observed that, the highest (1.32 g $plant^{-1}$) dry matter accumulation was recorded in treatment T_5 with sole Safed musli which was at par with treatment T_2 (3:1 row proportion) during first year. Safed musli + Pigeonpea in 1:2 row proportion (T_4) was recorded lowest (0.86 g $plant^{-1)}$ dry matter accumulation. Similar trend was also observed during second year. Pooled result indicated that highest dry matter accumulation g $plant^{-1}$ was recorded in treatment T_5 under sole Safed musli followed by treatment T_2 under Safed musli + Pigeonpea in 3:1 row proportion.

Dry matter yield kg ha^{-1}

On persual of data presented in Table 3, revealed that the dry matter yield (kg ha^{-1}) was ranged from 79.0 to 152.0 and 66.0 to 156.0 kg ha^{-1} during 2015-16 and 2016-17 respectively. From table, it was observed that, the highest (152.0 kg ha^{-1}) dry matter yield was recorded in treatment T_5 under sole Safed musli during first year. During second year 2016-17 highest dry matter yield (156.0 kg ha^{-1}) was recorded in treatment T_5 under sole Safed musli. Lowest (66.0 kg ha^{-1}) dry matter yield was recorded in treatment T_4 under Safed musli + Pigeonpea in 1:2 row proportion.

Pooled result indicated that highest (154.0 kg ha^{-1}) dry matter yield was recorded in treatment T_5 under sole Safed musli followed by treatment T_2 under Safed musli + Pigeonpea in 3:1 row proportion.

Available major nutrients after harvest

Available Nitrogen

On persual of data presented in Table 3, the available nitrogen as influenced by various row proportions was ranged from 234.05 to 254.10 kg ha^{-1} and 235.30 to 260.11 kg ha^{-1} in 2015-16 and 2016-17 respectively.

From table, it was revealed that the available nitrogen was significantly highest (254.10 kg ha^{-1}) with row proportion of Safed musli + Pigeonpea 1:2 (T4) which was at par with the treatment Safed musli + Pigeonpea in 3:1 row proportion (T2) and Safed musli + Pigeonpea in 2:2 row proportion (T3) while the lowest (240.05 kg ha^{-1}) in sole pigeon pea (T6) during 1st year.

However, during 2nd year data on available nitrogen showed that significantly highest available nitrogen (260.11 kg ha-1) was recorded with Safed musli + Pigeonpea in 1:2 row proportion (T4) which was at par with 2:1 row proportion (T1), while the lowest (235.30 kg ha^{-1}) in sole pigeon pea (T6) during 1st year.

Here it was observed that the gain of nitrogen was noted after harvest of Safed musli crop in all treatments in both the year. This may be due to inclusion of organic manure which contains appreciable amount of nitrogen and which resulted in building up or maintenance of N availability as observed by Bairathi *et al*. (1974) [2], Sharma *et al*. (1986) [9], Bhakare *et al*. (1991) [4] and Bangar *et al*. (2003) [3].

Available phosphorus

On persual of data presented in Table 3, the available phosphorus as influenced by various row proportions was ranged from 16.86 to 18.91 kg ha^{-1} and 17.00 to 19.90 kg ha^{-1} after harvest of Safed musli grown in 2015-16 and 2016-17 respectively.

From table, it was observed that the significantly highest (18.91 kg ha^{-1}) available phosphorus was recorded with the application Safed musli + Pigeonpea in 1:2 row proportion (T_4) which was significantly superior over T_1 (2:1 row proportion),T2 (3:1 row proportion) and T_6 (Sole Pigeonpea), while lowest (16.86 kg ha-1) was in T_6 (Sole Pigeonpea) during 1st year.

However, during 2nd year data showed that significantly highest available phosphorus (19.90 kg ha-1) was recorded with the application of Safed musli + Pigeonpea in 1:2 row proportion (T_4) however, statically at par with rest of the treatments except T_6 (Sole Pigeonpea).

The increased in available phosphorus status in all treatments might be due to residues (leaf litter) added through legumes Pigeonpea) in addition to application of recommended dose of FYM @ 20 t ha-1 to Safed musli crop. The appreciable built up in available phosphorus may be due to the influence of organic matter in increasing liable phosphorus in soil; through complexing of cations like Ca_2^+ which are mainly responsible for the fixation of phosphorus (Kharche *et al*.,2011) [7]. The findings are in agreement with the results reported by Katkar *et al*. (2005) [6] Chitale *et al*. (2003) [5] and Singh *et al*. (2008) [12].

Available potassium

On persual of data presented in Table 3, the available potassium as influenced by various row proportions was ranged from 283.51 to 290.75 kg ha-1 and 283.65 to 291.60 kg ha-1 after harvest of safed musli grown in 2015-16 and 2016-17 respectively.

From table, it was observed that the available potassium was significantly highest (290.75 kg ha-1) under safed musli + pigeonpea in 1:2 row proportion (T4) which was significant over treatment T1 (2:1 row proportion) and T2 (2:1 row proportion) during 1st year.

However, during 2nd year data indicated that the significantly highest available potassium (291.60 kg ha-1) was observed with the application of safed musli + pigeonpea in 1:2 row proportion (T4) which was at par with 3:1 row proportion (T2), 2:2 row proportion (T3), sole safed musli (T5), sole pigeonpea (T6).

The addition of leaf litter and root biomass intercropping increased the K content of soil. This might be due to the reduction of potassium fixation and release of K due to the interaction of organic matter with clay, besides the direct K addition in available K pool. Singh and Shrivastava (2002) [11] reported significantly increased in available K content due to application of FYM which helps to maintain the supply of K

by releasing the K from reserve source.

Available status of nitrogen, Phosphorus and Potassium (kg ha^{-1}) recorded and are presented in Table 3. Data in Table 3 and it revealed from the data after 2 cycles of experimentation, moderate gain of N and P was observed in case of sole pigeon pea. Similarly in case of potassium highest gain of potassium was observed in (T_5) sole Safed musli. Maximum gain in available Nitrogen (25.11 kg ha^{-1}), Phosphorus (3.90 kg ha^{-1}) and Potassium (10.60 kg ha^{-1}) was observed in (T_4) Safed musli + Pigeonpea 1:2 intercropping during 2 years of experimentation it might be due to addition of higher biomass added through legumes Pigeonpea.

Table 1: Number of roots, root length and root girth of Safed musli as influenced by Safed musli + pigeonpea intercropping system

Treatments	No. of Roots plant^{-1}			Root Length (cm)			Root Girth (mm)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T_1-Safed musli + Pigeonpea (2:1)	8.03	8.53	8.28	6.35	6.65	6.50	5.48	5.60	5.54
T_2-Safed musli + Pigeonpea (3:1)	9.25	10.20	9.70	7.00	7.24	7.12	5.95	6.05	6.00
T_3-Safed musli + Pigeonpea (2:2)	8.30	8.50	8.25	6.61	6.39	6.50	5.38	5.44	5.41
T_4-Safed musli + Pigeonpea (1:2)	7.75	7.80	7.78	6.59	6.68	6.63	5.66	5.59	5.63
T_5-Sole Safed musli	8.75	9.00	8.87	6.41	6.60	6.50	6.10	5.85	5.97
T6-Sole Pigeonpea	-	-	-	-	-	-	-	-	-
SE (m) ±	0.39	0.41	0.31	0.29	0.30	0.20	0.24	0.26	0.17
CD at 5%	1.14	1.20	0.93	0.50	0.75	0.59	0.63	0.45	0.51

Table 2: No. of Roots plant-^{1}, Safed musli fresh root yield (q ha^{-1}), dry matter accumulation and Dry Matter yield (kg ha^{-1}) of safed musli as influenced by Safed musli + pigeonpea intercropping system

Treatments	Safed musli fresh root yield (q $ha^{-1)}$			Safed musli dry root yield (tons $ha^{-1)}$			Dry matter accumulationplant^{-1} (g)			Dry matter Yield(kg ha-1)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T_1 - Safed musli + Pigeonpea (2:1)	24.43	22.54	23.48	4.15	3.84	3.99	0.98	0.99	0.98	88	89	88
T_2 - Safed musli + Pigeonpea (3:1)	33.4	30.44	31.92	5.67	5.17	5.42	1.12	1.1	1.11	128	118	123
T_3 - Safed musli + Pigeonpea (2:2)	22.55	21.6	22.07	3.83	3.67	3.75	0.98	0.9	0.94	88	89	88
T_4 - Safed musli + Pigeonpea (1:2)	13.31	12.38	12.84	2.26	2.1	2.18	0.86	0.8	0.83	79	66	72
T_5 - Sole Safed musli	32.14	30.22	31.18	5.46	5.13	5.3	1.32	1.3	1.31	152	156	154
T6 - Sole Pigeonpea	-	-	-	-	-	-	-	-	-	-	-	-
SE (m) ±	0.68	0.72	0.46	0.07	0.09	0.006	0.1	0.2	0.15	1.2	1	1.3
CD at 5%	2	2.1	1.4	0.23	0.3	0.15	0.31	0.21	0.26	7.5	8.1	5.3

Table 3: Nitrogen, Phosphorus and Potassium availability (kg ha^{-1}) by Safed musli in soil as influenced by Safed musli + pigeonpea intercropping system

Treatments	Available N (Kg ha^{-1})			Available P (Kg ha^{-1})			Available K (Kg ha^{-1})		
	2015-16	2016-17	+ or - over initial after completion of 2cycles	2015-16	2016-17	+ or - over initial after completion of 2cycles	2015-16	2016- 17	+ or - over initial after completion of 2cycles
T1 - Safed musli + Pigeonpea (2:1)	238.78	244.92	9.92	17.18	18.23	2.23	283.51	283.65	2.65
T2 - Safed musli + Pigeonpea (3:1)	241.32	243.72	8.72	17.25	18.37	2.37	283.76	284.36	3.36
T3 - Safed musli + Pigeonpea (2:2)	239.27	243.8	8.80	18.15	18.4	2.40	285.19	285.24	4.24
T4 - Safed musli + Pigeonpea (1:2)	254.1	260.11	25.11	18.91	19.9	3.90	290.75	291.6	10.60
T5 - Sole Safed musli	240.05	245.12	10.12	17.81	18.8	2.80	284.09	284.12	3.12
T6 - Sole Pigeonpea	234.05	235.3	0.30	16.86	17	1.00	284.5	284.56	3.56
initial value	235	-	-	16	-	-	281	-	-
SE (m) ±	5.1	5.5	-	0.7	0.8	-	3.4	3.5	-
CD at 5%	15.1	16.69	-	1.2	2.4	-	6.8	7.5	-

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