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Original Research Paper

Influence of Mulching and NPK Levels on Growth, Yield and Economics of Pearl Millet in Bael Based Agri-Horticultural System under Rainfed Vindhyan Region

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ABSTRACT

A field experiment was conducted during *kharif* season of 2013 to find out the effect of mulching and NPK levels on pearl millet (*Pennisetum glaucum*) in bael (*Aegle marmelos*) based agri-horti system under rainfed condition of Vindhyan region. There were twelve treatment combinations comprised of three levels of mulching (no mulch, wheat straw mulch and dust mulch) and four levels of RDF NPK (50%, 75%, 100%, 125%). The experiment was laid out under split-plot design with three replications. Significant improvement was recorded in growth and yield attributes viz., plant height, number of leaves per plant, number of tillers per plant, dry matter accumulation per plant, number of ears per plant, ear length, number of grains per ear, 1000-grain weight, grain yield, stover yield, harvest index (%), nutrient uptake and economic returns. Significantly higher yield of pearl millet (1908 kg/ha) was observed in the plot that received 125% RDF, which was found at par with the 100% RDF and in case of mulching, the maximum yield was observed with dust mulch (1942 kg/ha) than all other treatments. The application of dust mulch and 125% of the recommended dose of fertilizer (RDF) NPK (T_{12}) treatment have distinct superiority as compared to all other treatments under bael based agri-horti system and more suitable for moisture conservation practice in pearl millet.

INTRODUCTION

The agri-horticultural system is one among various land-use systems, which is most important in terms of economic returns to the farmers. The tree and crop components help each other by creating favourable conditions for their growth in such a way that the agri-horti systems provide an efficient land use and better economic return than the corresponding sole crop during early phase of the orchard establishment, and the interaction between the component is complementary in nature and advantageous under rainfed condition.

Selection of suitable crops and cropping system may be one of the strategies to mitigate the problems related to drought. The duration of traditional crops grown in rainfed areas is often longer than the effective season length. Short duration crops may be intercropped to make the best use of resources in an agri-horticultural system in which perennial fruit trees and crops as annual grown together. Crop production in agri-horticultural system also shares the benefits. For instance, interculture, weed control, tillage, mulching, etc. applied to the crop also benefit the trees in the agroforestry system (Dhyani et al. 2009). It is feasible to grow pearl millet with custard apple and guava.

The economic survival of the farming community of district Mirzapur (Vindhyan region) depends on the cultivation of short duration *kharif* crops under rainfed condition. Pearl millet is popularly grown in the region and also the fruit trees like guava and custard apple have been found promising under situation of Vindhyan region. Agri-horticultural system plays an important role, especially in semi-arid region where production of annual crops is not only low but also highly suitable. Fruit trees if suitability integrated under such farming system could significantly benefit the overall agricultural production, including conservation of soil and water with stability in production and income.

The nature of interactions between two components can be described on the basis of the observable net effect of one component on another in a system. In a system if the tree and crop components help each other, by creating favourable conditions for their growth in such a way that the agroforestry systems provides an efficient land use and better economic returns than the corresponding sole crops during the early phase of orchard establishment, then the interaction between the components may be complementary in nature and advantageous. Under rainfed condition and in

poor water holding capacity of Vindhyan region soils, growing short duration arable crops during *kharif* is the only option for most of the farmers.

Keeping the above facts in the view, an experiment was conducted to assess the effect of mulching and NPK levels on the growth and yield of pearl millet in bael (*Aegle marmelos*) based agri-horti system under rainfed condition of Vindhyan region.

MATERIALS AND METHODS

Site description and field experiment: The field experiment was conducted at agricultural research farm of Rajiv Gandhi South Campus, Barkachha (BHU), Mirzapur (U.P.) during *kharif* season of 2013, which is situated in the Vindhyan region of district Mirzapur at 25°10' latitude, 82°37' longitude and altitude of 147 meters above mean sea level; and the growth and yield parameters were observed. The initial physico-chemical properties of experimental plot are: bulk density (1.50 g/cm^3), particle density (2.59 g/cm^3), texture (Sandy clay loam), pH (1:2; 5.8), EC (0.28 dSm^{-1}), organic C (0.28%), available N (137.8 kg/ha), available P (4.60 kg/ha) and available K (185.7 kg/ha).

Experimental design and treatments: There were twelve treatment combinations of three levels of mulch (no mulch, wheat straw mulch @ 5 tone/ha and dust mulch and four levels of RDF (50%, 75%, 100%, 125%). The experiment was laid out in split plot design (SPD) during *rabi* season with 12 treatment combinations (three main plot and four subplot treatments) and three replications. The details of various treatments applied to pearl millet crop along with the symbols used are as T_1 (M_0F_1), T_2 (M_0F_2), T_3 (M_0F_3), T_4 (M_0F4), T_5 (M_1F_1), T_6 (M_1F_2), T_7 (M_1F_3), T_8 (M_1F_4), T_9 (M_2F_1), T_{10} (M_2F_3), T_{11} (M_3F_4), and T_{12} (M_1F_4). Experimental field was prepared by harrow ploughing and two deep ploughing by tractor drawn cultivator followed by pre-sowing irrigation. The field was finally prepared by disc harrow followed by planking. In order to create ideal condition for good germination, pre-sowing irrigation was given 9 days before sowing. Full care was taken to level the plots uniformly and grass was removed from the plots. Certified seed of pearl millet variety ICTP-8203 was sown with a spacing of 40' 10 cm in the plots having a net plot area of 17m^2. Different levels of mulches i.e., no mulch, wheat straw mulch @5 tone/ha and dust mulch and RDF NPK @ 50% (40-20-20), @ 75% (60-30-30), @ 100% (80-40-40) and @ 125% (100-50-50) kg/ha respectively, were applied to pearl millet. Nitrogen and phosphorus were applied through di-ammonium phosphorus and remaining N through urea, uniform based application of potassium was made through mureate of potash, respectively to all the plots. Intercultural operations were done to ensure normal growth of the crop. All the grass was removed from the land surface and all crop growth and yield attributes, data has been taken from the field at 20, 40, 60 DAS (days after sowing) and at harvest of pearl millet. Plant height of marked plants was recorded in each plot at different growth stages. Five plants are marked randomly and tagged in each replicate plot and the height was measured from the base of the plant to the upper most fully stretched leaf. The average of all the observations from each plot was worked out and designed as mean plant height.

Statistical analysis: Data were assessed by Duncan's multi-

Table 1: Main effects of mulching and NPK levels on growth attributes of pearl millet at various stages.

Treatment	Plant height (cm)				Number of leaves per plant				Number of tillers per plant				Dry matter accumulation per plant (g)			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
Mulching (M)																
No mulch	45.8b	125.0b	195.0a	213.5b	9.4a	13.0b	21.0a	17.7a	1.44a	2.18a	2.79a	2.93a	5.7b	36.6c	92.9b	126.7b
Wheat straw mulch	46.3b	129.5a	198.1a	231.4a	9.8a	14.3a	21.5a	18.7a	1.52a	2.38a	2.87a	3.03a	6.5a	41.8b	100.2a	131.7a
Dust mulch	50.7a	130.7a	199.5a	237.8a	10.3a	15.3a	21.8a	18.3a	1.58a	2.41a	2.97a	3.07a	6.8a	48.4a	100.5a	132.5a
NPK Level (F)																
50% RDF	36.4d	118.2d	186.0b	209.8c	7.2c	10.0c	16.2c	13.5c	1.07c	1.73c	1.96c	2.09c	5.4b	26.6c	84.8c	111.3c
75% RDF	44.4c	123.7c	199.1a	228.2b	9.2bc	14.2b	21.8b	18.6b	1.46b	2.27b	2.80b	3.00b	5.8b	37.6b	94.4b	121.2b
100% RDF	52.1b	133.1b	202.2a	233.8ab	10.8b	15.4ab	23.2a	19.8ab	1.76a	2.62a	3.36a	3.44a	7.1a	51.9a	105.9a	142.9a
125% RDF	57.7a	138.7a	202.8a	238.6a	12.3a	17.2a	24.6a	20.6a	1.78a	2.64a	3.39a	3.51a	7.3a	52.7a	106.3a	145.8a
M	*	*	NS	*	NS	*	NS	NS	NS	NS	NS	NS	*	*	*	*
F	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
M×F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	*

Means with different alphabets indicate significant difference between treatments by Duncan's multiple range test at £ 0.05. *,**significantly different at 0.05 and 0.01 probability levels, respectively. NS: Not significant.

Table 2.: Main effects of mulching and NPK levels on yield attributes, grain yield, stover yield and harvest index of pearl millet.

Treatment	Yield attributes							Nutrient uptake by plant (kg/ha)		
	Number of (kg/ha)	Ear length (kg/ha)	Number of Index (%)	1000-grain ears per plan	Grain yield (cm)	Stover yield grains per ear	Harvest weight (g)	N	P	K
Mulching										
No mulch	1.23b	19.8b	1347a	8.3b	1090c	3373c	24.4c	63.7c	19.9b	113.2b
Wheat straw mulch	1.38ab	20.3a	1377a	9.1ab	1681b	3932b	29.9b	80.7b	21.7a	126.8a
Dust mulch	1.61a	20.9a	1386a	9.3a	1942a	4315a	31.1a	96.6a	22.5a	129.0a
NPK level										
50% RDF	1.16c	18.22b	1280c	7.08d	1229c	3514c	25.91b	42.4d	19.5d	113.4c
75% RDF	1.33b	19.33b	1364b	8.64c	1634b	3971b	29.15ab	69.1c	20.7c	124.2b
100% RDF	1.53ab	21.56ab	1402ab	9.54b	1846ab	4067ab	31.22a	92.9b	21.6b	125.1ab
125% RDF	1.61a	22.19a	1418a	10.18a	1908a	4153a	31.48a	116.9a	22.8a	129.4a
M	*	*	NS	*	**	**	*	*	*	*
F	*	*	**	*	**	**	*	*	*	*
M×F	*	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means with different alphabets indicate significant difference between treatments by Duncan's multiple range test at ≤ 0.05. *,**significantly different at 0.05 and 0.01 probability levels, respectively. NS: Not significant.

ple range tests (Duncan 1955) with a probability P=0.05. Least significant difference (LSD) between the mean values was evaluated by a one-way analysis of variance by using SPSS version 10.0.

RESULTS AND DISCUSSION

Growth Parameters

Plant height as affected by mulching, showed significant effect in all the crop growth stages except at 60 DAS. Data showed that the dust mulch treatment was statistically at par with wheat straw mulch which recorded maximum plant height (237.83 cm) at harvest. Plant height varied significantly by NPK levels at all the stages of observation. The maximum momentum in growth rate was observed between 20th and 40th day after sowing. During the initial phase of crop growth (up to 40 DAS), significantly higher plant height was exhibited by the treatment 125% RDF over others. Interaction effect between mulching and NPK levels on plant height was found nonsignificant at all the stages of observation. A significantly lower plant height was recorded in control, i.e. no mulch as compared to all other treatments (Table 1). The similar results were also reported by Kaushik & Gautam (1987), Pareek & Shaktawat (1988), Mishra (1996), Kumar et al. (1995) and Maliwal et al. (1985).

Number of leaves per plant: They did not differ significantly due to mulching at all the crop growth stages except at 40 DAS. Data showed, at 40 days stage, that the dust mulch being statistically at par with wheat straw mulch, recorded maximum number of leaves per plant (15.33) but both were significantly superior over control. Maximum NPK level (125% RDF) claimed the highest number of leaves per plant and registered significant superiority over 50% RDF and 75% RDF at all the growth stages but did not differ significantly with 100% RDF except at 40 DAS. Interaction effects between mulching and NPK levels on the number of leaves was found nonsignificant at all the stages (Table 1). The similar results were also reported by Trivedi et al. (1994), Shiahd Buse (1989), Yadav et al. (1989), Chhangani et al. (2000) and Shiva Dhar Das et al. (2007).

Number of tillers per plant: Due to mulching, number of tillers per plant did not differ significantly at all the stages of observation. NPK levels produced significant variation in number of tillers per plant of pearl millet at all the stages. Maximum number of tillers per plant were observed under highest NPK level of 125% RDF, which proved significantly superior than the 50% RDF and 75% RDF, respectively. However, 125% RDF and 100% RDF did not differ significantly among themselves. Interaction effects between mulching and NPK levels on the number of tillers per plant was found nonsignificant at all the stages of observation (Table 1). These results are supported by the findings of Kaushik and Gautam (1987), Pareek & Shaktawat (1988), Mishra (1996), Kumar et al. (1995) and Maliwal et al. (1985).

Dry matter accumulation: As affected by mulching and NPK levels, dry matter accumulation was found significant at all the stages. Data revealed that dust mulch was statistically at par with wheat straw mulch at all the stages of crop except at 40 DAS. At 40 DAS, dust mulch recorded significantly higher dry matter than wheat dust mulch and no mulch, respectively. At all the stages, 125% RDF was found at par

Table 3.: Economics of experiment on pearl millet as influenced by mulching and NPK levels under bael based agri-horti system.

S.No.	Treatment	Treatment cost (Rs ha^{-1})	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Bael yield (kg ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit : Cost Ratio
1.	M_0F_1	15,987	1160	3444	1600	45,943	29,956	2.87
2.	M_0F_2	16,758	1362	3672	1600	48,843	32,085	2.91
3.	M_0F_3	17,685	1468	3720	1600	50,182	32,497	2.84
4.	M_0F_4	19,021	1499	3763	1600	50,646	31,625	2.66
5.	M_1F_1	27,539	1455	3723	1600	50,040	22,501	1.82
6.	M_1F_2	28,310	1658	3952	1600	52,940	24,630	1.87
7.	M_1F_3	29,237	1764	4000	1600	54,279	25,042	1.86
8.	M_1F_4	30,573	1795	4043	1600	54,743	24,170	1.79
9.	M_2F_1	17,927	1636	3915	1600	52,595	34,668	2.93
10.	M_2F_2	18,698	1788	4143	1600	54,920	36,221	2.94
11.	M_2F_3	19,625	1894	4191	1600	56,259	36,634	2.87
12.	M_2F_4	20,961	1925	4234	1600	56,723	35,762	2.71

Note: Market price of produce: Seed, Rs.11.5 kg^{-1}; Stover, Rs. 2.5 kg^{-1}; Bael, Rs. 15 kg^{-1}, Common cost of cultivation: Rs. 13,979 ha^{-1}

with 100% RDF but recorded significantly higher dry matter accumulation than the rest of the treatments. The lowest dry matter accumulation was obtained in 50% RDF. Interaction between mulching and NPK levels for dry matter accumulation was found significant at 60 DAS and at harvest. Each NPK level was significantly different among themselves with all mulching except at 50% RDF and 100% RDF where the wheat straw mulch and no mulch were at par with each other. Each mulching treatment was significantly different at all the NPK levels except 100% RDF and 125% RDF where response was nonsignificant. The highest dry matter accumulation was found (111.53g) at 60 DAS and at harvest (149.90g) where dust mulch was used with 125% RDF treatment combination (Table 1). This is in agreement with the earlier findings of Moody et al. (1963), Ali (1976), Upadhyay (1979), Mishra (1996), Shivran (2003), Rana (2006) and Singh & Mongia (1990), who noted that mulching helped in higher dry matter accumulation.

Yield Parameters

Number of ears per plant: It was significantly influenced by application of mulching. Scanning of the data revealed that, dust mulch treatment recorded significantly the highest number of ears per plant than no mulch but found at par with wheat straw mulch. Between NPK levels, maximum ears per plant was recorded with 125% RDF, which was significantly superior over its lower levels. The interaction between mulching and NPK levels for ear per plant was found significant. An inspection of the data reveals that a significantly higher number of ears per plant were recorded under dust mulch with 125% RDF treatment combination (1.87) next followed by dust mulch with 100% RDF (1.70), respectively. However, minimum ears per plant was recorded in no mulch with 50% NPK level (Table 2). The results are corroborated with the findings of Mishra (1996), Shivran & Rana (2003), Yadav et al. (2009), Amini et al. (2013), Choudhary et al. (2012), Gosavi et al. (2009) and Swain et al. (2007).

Ear length: As affected by different mulching and NPK levels, ear length statistically was found significant. Data revealed that dust mulch recorded maximum ear length (20.89cm) which was significantly superior to no mulch. However, ear length in dust mulching was statistically at par with wheat straw mulching. Ear length of pearl millet increased significantly with increase in NPK levels up to the highest NPK level of 125% RDF. The interaction effect of two factors on ear length was found non-significant (Table 2). This is in agreement with the earlier findings of Mishra (1996), Shivran & Rana (2003), Yadav et al. (2009), Amini et al. (2013), Choudhary et al. (2012), Gosavi et al. (2009) and Swain et al. (2007).

Number of grains per ear: Due to mulching and NPK levels, number of grains per plant did not show significant variation. The maximum grain per ear was found in the case of dust mulch (1386) and 125% RDF (1418). The interaction between mulching and NPK levels for number of grains per ear was found nonsignificant (Table 2). These findings are in close agreement with Mishra (1996), Shivran & Rana (2003), Yadav et al. (2009), Amini et al. (2013), Choudhary et al. (2012), Gosavi et al. (2009) and Swain et al. (2007).

1000-grain weight: Due to dust mulching 1000-grains have a maximum weight (9.27g), which has exerted significant impact and statistically was found at par with wheat straw mulch, but both treatments produced significantly superior 1000-grain weight over no mulch. The levels of NPK significantly affected the 1000-grain weight of pearl millet and values increased significantly with increase in each NPK levels up to the highest level of 125% RDF. The interaction between mulching and NPK levels for 1000-grain weight was found nonsignificant. These results are in agreement with the findings of Pareek & Shaktawat (1988), Mishra

(1996), Shivran & Rana (2003), Yadav et al. (2009), Amini et al. (2013), Choudhary et al. (2012), Gosavi et al. (2009) and Swain et al. (2007).

Grain yield: As affected by mulching and NPK levels, grain yield was found significant. The mulching treatment was found significantly different with each other for grain yield. The grain yield was found in the order of dust mulch > wheat straw mulch > no mulch. Wheat straw mulch recorded 35.7 per cent higher yield than no mulch while dust mulch registered higher yield which was 43.9 per cent more over no mulch (Shivran 2003, Rana 2006, and Singh & Mongia 1990). Increasing the level of NPK significantly enhanced the grain yield except at the highest level (125% RDF), which was found at par with the 100% RDF. Maximum and minimum grain yield obtained with 125% RDF (1908 kg/ha) and 50% RDF (1229 kg/ha), respectively. These results are supported by Pareek & Shaktawat (1988), Tetarwal & Rana (2006) and Yadav et al. (2009). The interaction between mulching and NPK levels for grain yield was found nonsignificant (Narayan & Joshi 2000, Kumar et al. 2008, Singh et al. 2010 and Ashok & Shivdhar 2010).

Stover yield: As influenced by mulching and NPK levels, maximum stover yield in pearl millet was registered under dust mulch treatment which was significantly higher than wheat straw mulch. Stover yield increased significantly with an increase in NPK levels up to 100% RDF, further increase in NPK level (125% RDF) could not produce significant difference. The interaction between mulching and NPK levels for stover yield was found nonsignificant. These findings confirm with those of Narayan & Joshi (2000), Kumar et al. (2008), Singh et al. (2010) and Ashok & Shivdhar (2010).

Harvest index: As influenced by mulching treatments and NPK levels, mulching showed significant variation among themselves for harvest index. The maximum values were obtained under dust mulch, followed by wheat straw mulch and no mulch, respectively. Variations due to fertility levels were significant. An inspection of the data revealed that 125% RDF was at par with 100% RDF, but produced significantly higher harvest index than remaining NPK levels. The lowest harvest index was observed in 50% RDF level. The interaction between mulching and NPK levels for harvest index was found to be nonsignificant. These results are supported by the findings of Narayan & Joshi (2000), Kumar et al. (2008), Singh et al. (2010) and Ashok & Shivdhar (2010).

Nutrients Uptake

***Nitrogen uptake*:** In mulching treatments, dust mulch recorded significantly higher nitrogen uptake than wheat straw mulch and no mulch, respectively. Further, as the dose of NPK was increased from 75% RDF to 125% RDF, the nitrogen uptake increased significantly up to 125% RDF. The maximum nitrogen uptake was recorded with 125% RDF, which was significantly higher than the lower levels of RDF. The interaction between mulching and NPK levels for nitrogen uptake was found nonsignificant.

***Phosphorus uptake*:** Phosphorus uptake as affected by mulching indicated that dust mulch recorded significantly higher uptake of phosphorus than no mulch, but being at par with wheat straw mulch. There was also a significant influence on the phosphorus uptake due to NPK levels. The maximum phosphorus uptake was recorded with 125% RDF, which was significantly higher than their lower NPK levels. The interaction between mulching and NPK levels for phosphorus uptake was found nonsignificant.

Potassium uptake: Mulching treatments exerted a significant impact on potassium uptake and scanning of the data revealed that dust mulch recorded maximum potassium uptake which was statistically at par with wheat straw mulch but both treatments produced significantly superior potassium uptake over no mulch. Fertility levels improved potassium uptake significantly. The maximum potassium uptake was recorded with 125% RDF which was statistically at par with 100% RDF and 75% RDF, but was found significantly higher than 50% RDF, respectively. The interaction between mulching and NPK levels for potassium uptake was found nonsignificant.

Effect of Fruit Tree Species and NPK Level on Economics

Economics of different treatments regarding the cost of cultivation, clearly indicates that the cost of cultivation was higher (Rs 30,573 per ha) in wheat straw mulching with highest NPK level of 125% RDF. No mulch with 50% RDF treatment combination (M_0F_1) showed the minimum cost of cultivation (Rs 15,987 per ha). The data recorded under different components of economics revealed that the gross return increased with increasing grain and stover yield of pearl millet crop under different treatment combinations. It is evident from the data that, among the various treatment combinations, dust mulch with 125% RDF (M_2F_4) obtained maximum gross return (Rs 56,723 per ha). No mulch with 50% RDF (M_0F_1) recorded minimum gross return (Rs 45,943 per ha).

The highest net return M_2F_3 (Rs 36,634 per ha) was recorded by dust mulching with 100% RDF application closely followed by dust mulch (M_2F_2) with 75% RDF. The minimum net return (Rs 22,501 per ha) was obtained under no mulch with 50% RDF (M_0F_1).

The data related to B:C ratio recorded variations among different treatment combinations. The dust mulching with 75% RDF (M_2F_3) recorded highest B:C ratio (2.94) whereas wheat straw mulching with 125% RDF (M_1F_4) was found

the least beneficial with minimum B:C ratio (1.79).

Characteristics of Bael (*Aegle marmelos*)

Growth parameters: During the investigation, due to short plant growth not major changes were observed in growth parameters of bael. Plant height, plant spread and stem diameter ranged from 5.82-5.90 m, 10.84-10.98 feet and 32.41-32.82 cm, respectively.

Yield: The average yield of bael fruits was 1600 kg/ha. It is common in all treatment because the pearl millet crop was grown between two rows of bael trees.

CONCLUSIONS

1. The maximum value of growth as well as yield parameters and yield of pearl millet were obtained with the application of dust mulch and 125% of the recommended dose of fertilizer (RDF) i.e., 100, 50 and 50 kg/ha nitrogen, phosphorus and potassium, respectively under bael based agri-horti system.
2. The application of dust mulch showed its distinct superiority over wheat straw mulch and proved to be more suitable for moisture conservation practice in pearl millet. The nutrient treatment of 100% RDF (80, 40 and 40 kg/ha nitrogen, phosphorus and potassium) appeared to be optimum for pearl millet in bael based agri-horti system.
3. The highest net return could be realized with the application of dust mulch and 100% RDF in pearl millet for bael based agri-horti system under rainfed conditions of Vindhyan region.

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