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Original Research Paper

Comparative Performance and Production Potential of Hybrid Maize (*Zea mays* L.) with Urdbean (*Vigna mungo*) and Mungbean (*Vigna radiata*) Under Different Planting Patterns in Alluvial Soil

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ABSTRACT

A field experiment was conducted during *kharif* season of 2013 on sandy loam soil. The experiment aimed to evaluate the performance of hybrid maize with urdbean and mungbean under different planting patterns. In this investigation, 9 treatment combinations viz., maize with normal (1:1), paired (2:2) and strip (3:3) planted urdbean (*Vigna mungo*) and mungbean (*Vigna radiata*) along with all the three crops in their sole stands were tested in randomized block design with 3 replications. The study revealed that strip planted maize+urdbean (3:3) being on par with maize+mungbean (3:3) recorded significantly highest values of growth parameters, nodulation habitat, yield attributes and yield of maize in terms of grain yield (45.6 q/ha) and stover yield (77.8 q/ha), except phenological parameters and mortality %. In terms of protein in maize grains and nitrogen, phosphorus and potassium content in grains and stover, strip (3:3) planted maize proved its superiority over sole and normal (1:1) planted maize. Likewise, in intercrops, all the growth parameters, yields, nutrients content and protein yield were statistically superior in their sole as compared to normal (1:1), paired (2:2) and strip (3:3) planting with maize, except plant height.

INTRODUCTION

Maize is third most important cereal crop in India after rice and wheat. In India, it occupies an area of about 9.08 million ha and produces 23.29 million tonnes of grains with an average productivity of 2563 kg/ha (2013-14). The recommended hybrids, in general, have given 60% to 80% or more grain yield than the local varieties with an average yield level of 6 tons or more per hectare (Anonymous 2013-14).

India is the world's largest homeland of vegetarian population and the world leader in pulse production and provider of protein supplements (Singh et al. 2007). Declining trends in area, production and yield of pulses is recorded in the Indo-Gangetic plains, popularly known as the pulse basket of India. Indian pulse production has been stuck between 14 and 15 mt since mid-nineties, resulting in poor consumption (60g/day/capita in 1951 to 33g/day/person at present). The agro-ecosystems of this region are becoming fragile and the climate change is posing a potential threat for crop production, especially to mungbean and urdbean.

In intercropping system involving legume and non legume, legume may provide nitrogen, benefiting non-legume component, which improves nitrogen content and protein yield (Dwivedi et al. 2015). Intercropping of cereal-legumes culture is widely practiced by small farmers in tropical and sub-tropical regions of the world. In intercropping system, all the environmental resources utilized to maximize crop production per unit area per unit time. Also the risk may be minimized in intercropping (Woolley & Davis 1991). In the absence of nitrogenous fertilizer, intercropped legumes will fix nitrogen from the atmosphere and not compete with maize for nitrogen resources (Adu-Gyamfi et al. 2007).

Days taken to tasselling and maturity, nitrogen contents, yields per hectare, protein content and protein yield in maize was superior in maize+mashbean intercropping with paired planting geometry, than their sole cropping with other geometries, except mortality % (Dwivedi et al. 2015). Intercropping of maize with urdbean resulted in 9.7 to 11.5 percent higher grain yield than sole maize grown with normal and paired row planting, respectively. However, the yield from the maize+urdbean cropping system was statistically on par with that of maize+soybean. Shivay & Singh (2003) found that yield attributes (cobs per plant, cob length, grains per cob, grain weight per cob and weight of cobs/plant and yields

were significantly improved in paired row maize (40/80 cm) + one row of mungbean compared to sole maize but was at par with paired row maize +2 rows of mungbean (Shivran & Rana 2003). Uptakes of N, P and K by blackgram were higher in the sole planting as against maize+blackgram (2:1) intercropping system. They further reported that number and dry weight of nodules was highest in sole blackgram (Dwivedi et al. 2012). The available soil N, P and K content varied with the intercrops. However, maize+soybean followed by maize+black gram recorded the highest available soil N at 1:1 row ratio and available soil P and K at 2:1 row ratio (Padhi & Panigrahi 2006).

MATERIALS AND METHODS

A field experiment was conducted during *kharif* season 2013 at Crop Research Centre (Chirauri) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), located at a latitude of 29° 40' North and longitude of 77° 42' East with an elevation of 237 metres above mean sea level. The mean weekly maximum temperature was 39.2°C which was recorded in the last week of June. It declined gradually and reached to its minimum at the time of harvest. Minimum temperature follows the same trend as of maximum temperature, though the lowest temperature was 18.9°C during the third week of October. The mean weekly relative humidity at 7.00 and 14.00 hrs varied from 80.8 to 59.9 and 73.7 to 23 per cent, respectively. The total rainfall received during the crop period was 651.6 mm. The experimental field was well drained, sandy loam in texture (46.2% sand, 18.4% silt and 17.4% clay by Bouyoucos hydrometer method) and slightly alkaline in reaction (pH 7.8). The soil was medium in organic carbon (0.542 %), organic matter (0.934 %), available phosphorus (14.7 kg/ha) and potassium (177.9 kg/ha) but low in available nitrogen (201.2 kg/ha) with an electrical conductivity (1:2, soil: water suspension, Solbridge conductivity meter method) and bulk density (Core sampler method) of 1.6 dS/m and 1.42 mg/m^3, respectively. All the physico-chemical properties were analysed as per the standard procedures given by Jackson (1973). In this investigation 9 treatment combinations viz., maize with normal (1:1), paired (2:2) and strip (3:3) planted urdbean and mungbean along with all the three crops in their sole stands were tested in randomized block design with 3 replications. The crops were grown with the recommended agronomic package of practices. The seeds were placed manually in the furrows at a plant to plant distance of 20 and 10 cm with a seed rate of 20, 15 and 15 kg/ha for maize urdbean and mungbean, respectively and sown on 25th July 2013. The 100 per cent NPK (for maize) is characterized by 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha two hand weeding, first at 25 days after sowing and second at 45 days after sowing, were done manually for controlling weeds. The maize crop is highly sensitive to water stress, both excess and short, therefore, surface drains were opened just after sowing to ensure proper drainage. Rains commensurate well with the crop water requirement at critical stages so that only one irrigation was applied at 52 DAS. Observations on % mortality, growth parameters viz., plant height and number of leaves/plant, phenology, nodules dry weight and yield attributes were recorded at harvest stage of crops determined as per standard procedure. The yield was estimated by the produce obtained from net plot area, treatment-wise and finally expressed at 14 % moisture. Content of nitrogen, phosphorus and potassium in maize and urdbean/mungbean (Tandon 1998) were multiplied by 5.73 and 6.25 for protein content, and after that multiplied with grain yield (q/ha) for protein yield. The data obtained were subjected to statistical analysis as outlined by Gomez & Gomez (1984). The treatment differences were tested by using "F" test and critical differences (at 5 per cent probability).

RESULTS AND DISCUSSION

Mortality %: Maize+mungbean (3:3), being on par with maize+urdbean (3:3) showed the highest mortality in maize as compared to rest of the treatments (Table 1a). However, the lowest mortality (5.7%) was recorded in maize+urdbean (1:1) followed by sole maize. Similar findings were also reported by Dwivedi et al. (2015).

The plant mortality varied from 4.6% in maize+urdbean (1:1) to 7.1 in maize+urdbean (3:3) in which urdbean sole registered the significantly higher plant mortality as compared to maize+urdbean in different row ratios (Table 1b and 1c). Although, the minimum per cent was obtained under strip planted maize+urdbean (3:3). The similar trend was noticed in mungbean with regards to plant mortality. The highest plant mortality of 7.6% was obtained in strip planted mungbean (3:3). However, it was statistically inferior to maize+mungbean (1:1).

Growth parameters: At maturity, the tallest plants (184.9 cm) were obtained under maize+mungbean (3:3) treatment. Likewise strip planting of maize+urdbean/mungbean (3:3) observed maximum number of green leaves (Table 1a). However, the differences between all stages were statistically not significant. Whereas, the shortest plant height (167.2 cm) and minimum numbers of green leaves (8.1) were noticed in sole planted maize. The increased values of growth parameters were probably due to the fact that intercrop legume will fix nitrogen from the atmosphere which can be utilized by maize coupled with better resource utilization by border rows due to lesser crop weed competition. Similar findings were also reported by Sadashiv (2004).

At maturity (Table 1b and 1c), strip planted urdbean (75.4 cm) and mungbean (90.4 cm) remained on par with paired planting (2:2) producing significantly tallest plants as compared to normal planting (1:1). However, sole planted urdbean (8.7) and mungbean (8.2) noticed significantly taller plants and the number of green trifoliate leaves than 1:1, 2:2 and 3:3 row ratio, even interacted on par with themselves. This might be due to more penetration of light, lesser competition and better utilization of resources in sole as compared to paired/strip planting with maize. A similar opinion was also put forward by Pandita et al. (2000) and Pathak & Singh (2008).

Phenology: The maize took about 41.3 to 44.7 and 83.0 to 85.0 days to tasselling and maturity, respectively (Table 1a). There was no significant variation among sole, normal paired and strip planted maize in this regard, except days to tasselling which remained on par among themselves. Interestingly, maize took a significantly lesser number of days for tasselling under paired planting as compared to sole and strip planted maize. The probable reason for required more days to tasselling and maturity was due to border effects. Further, the crop utilized the resources in a better way and sizeable amount of nitrogen fixed by urdbean and mungbean can also be utilized by maize crop which delayed the maturity in maize.

Urdbean (42.7 and 73.1) and mungbean (42 and 72.8) crop took a lesser number of days for flowering and maturity under paired planting as compared to other planting geometries. Although, the differences were not significant (Table 1b and 1c). Similar findings were also reported by Dwivedi et al. (2015).

Dry weight of nodules per plant: Significantly, more dry weight of nodules per plant was observed under urdbean sole (148.5 mg) as compared to normal maize+urdbean (144.0 mg) and paired maize+urdbean (135.1). However, significantly lowest dry weight of nodules per plant observed under strip planting which was 11.8 per cent lower from urdbean sole (Table 1b and 1c). Significantly more dry weight of nodules per plant was observed under mungbean sole (145.1 mg) as compared to normal maize+mungbean (137.4 mg), paired maize+mungbean (130.2) and strip planted maize+mungbean (123.9 mg). However, significantly lowest dry weight of nodules per plant observed under strip planting which was 17.1 percent less from mungbean sole. The highest uptake was directly related to root growth in terms of weight root nodules. Similar results were also reported by Tripathi et al. (2008).

Yield and yield attributes (number of cobs per plant, number of grains per cob, grain yield per plant, shelling per cent, grain and stover yield per hectare) of maize: As per the data presented in Table 1a, significantly more number of cobs/plant (1.27) was recorded in strip planted maize, maize+urdbean/mungbean (3:3) as compared to sole maize (1.17) and maize+urdbean (1:1) treatment (1.18). This might be due to better light use efficiency, water uptake, nutrient absorption and enzymatic activities in maize when intercropped with legume. Our results were also supported by Evans et al. (2001).

The total number of grains/cob varied from 445.3 to 481.7 in maize sole and maize+mungbean (3:3), respectively (Table 1a). The strip planted maize which was on par with paired planted maize, resulted into significantly more number of grains/cob than maize sole and maize+ urdbean/mungbean (1:1).

The strip planted maize+mungbean (3:3) produces a significantly higher grain yield/plant (175.71g) as compared to statistically on par with strip maize+urdbean, paired maize+mungbean/maize+urdbean (2:2) grain yield/plant (174.1g, 173.8g, 172.6g respectively) (Table 1a). However, the maize sole significantly has lower grain yield/plant (168.5 g). Increase in values of yield attributes were probably due to more dry matter accumulation. Our results were also supported by Shivran & Rana (2003).

The shelling percent varied from 81.73 to 85.00 in maize sole and maize+urdbean strip intercropping, respectively. Although, the differences between paired planted maize+urdbean (84.30) and strip planted maize+mungbean (84.93) were statistically alike (Table 1a).

Significantly higher grain yield (45.6 q/ha) of maize was noticed under maize+urdbean strip (3:3) intercropping system as compared to all the other treatments (Table 1a), except maize+mungbean (3:3). The increase over sole maize was to the tune of 6.5 per cent. A grain yield of 44.5-44.8 q/ha was obtained under paired planting which was statistically on par with maize+mungbean (3:3), strip planting (45.2 q/ha) and normal planted maize+urdbean (44.3 q/ha). However, significantly the lowest grain yield (42.8 q/ha) was recorded in sole maize. The increase in grain yield was may be due to more photosynthetic activities in maize crop due to more exposure to sunlight, besides an increase in values of yield attributes. These results were also put forward by Shivran & Rana (2003).

The strip planted maize+urdbean (77.4 q/ha), being on par with strip planted maize+mungbean (76.8 q/ha) and paired planted maize+urdbean (76.8 q/ha) resulted into a significantly high stover yield as compared to all other treatments. The lowest stover per hectare (72.8q/ha) was recorded in maize sole. The maize grown with urdbean at 2:2 and 3:3 row ratio produces 3.6 and 4.6 q/ha more stover than sole maize (Table 1a).

Table 1a: Mortality (%), growth parameters, phenology, yield attributes and yield of maize as influenced by various treatments.

Treatment	Mortality (%)	Growth parameters (at maturity)		Phenology		Yield attributes				Yield	
		Plant height (cm)	Number of green leaves	Days taken to Tesseling	Days taken to Maturity	Cobs/ plant	grain rows/ cob	grain yield (g/plant)	Shelling (%)	Grain yield (q/ha)	Stover yield (q/ha)
Maize sole	5.7	167.2	8.1	43.7	83.1	1.17	14.1	168.5	81.73	42.8	72.8
Maize+Urdbean (1:1)	5.6	176.5	8.4	43.3	84.0	1.18	14.3	169.2	82.70	43.9	74.4
Maize+Mungbean (1:1)	5.8	178.4	8.3	42.7	83.0	1.20	14.1	171.0	83.00	43.7	74.0
Maize+ Urdbean (2:2)	6.5	180.4	8.6	42.3	85.0	1.25	14.7	172.6	84.30	44.8	76.4
Maize+Mungbean (2:2)	7.2	182.6	8.7	41.3	84.7	1.24	14.6	173.8	83.83	44.5	75.5
Maize+Urdbean (3:3)	7.4	184.3	9.2	44.7	83.8	1.27	15.3	174.1	85.00	45.6	77.4
Maize+Mungbean (3:3)	7.9	184.9	8.9	44.3	83.4	1.27	14.9	175.7	84.93	45.2	76.8
S.Em.±	0.2	0.4	0.2	0.40	0.5	0.02	0.7	1.1	0.33	0.3	0.4
C.D. (P=0.05)	0.7	1.4	NS	1.2	NS	0.05	NS	3.3	1.03	0.8	1.4

Table 1b: Mortality (%), growth parameters, phenology, nodule dry weight, yield attributes and yield of urdbean as influenced by various treatments.

Treatment	Mortality (%)	Growth parameters (at maturity)		Phenology		Yield attributes			Yield	
		Plant height (cm)	Number of green trifoliate leaves	Days taken to Flowering	Days taken to Maturity	Nodule dry weight (mg)/plant	Bran ches/ plant	Pods/ plant	Grain yield (g/plant)	Grain yield (q/ha)	Straw yield (q/ha)
Urdbean Sole	6.7	72.3	8.7	43.3	73.5	148.5	4.0	30.2	7.5	8.1	18.5
Maize+ Urdbean (1:1)	4.6	72.5	7.5	43.0	72.7	144.1	3.8	28.6	7.0	4.5	15.2
Maize+ Urdbean (2:2)	6.3	75.3	7.2	41.7	72.6	135.1	3.6	25.9	6.5	4.4	14.0
Maize+Urdbean (3:3)	7.1	75.4	7.0	42.7	73.1	132.8	3.4	24.4	6.1	4.3	13.9
S.Em.±	0.4	0.1	0.2	0.9	0.8	0.5	0.1	0.2	0.2	0.2	0.2
C.D. (P=0.05)	1.5	0.3	0.6	NS	NS	1.8	0.4	0.6	0.5	0.7	0.5

Table 1c: Mortality (%), growth parameters, phenology, nodule dry weight, yield attributes and yield of mungbean as influenced by various treatments.

Treatment	Mortality (%)	Growth parameters (at maturity)		Phenology		Yield attributes			Yield	
		Plant height (cm)	Number of green trifoliate leaves	Days taken to Flowering	Days taken to Maturity	Nodule dry weight (mg)/plant	Bran ches/ plant	Pods/ plant	Grain yield (g/plant)	Grain yield (q/ha)	Straw yield (q/ha)
Mungbean Sole	6.7	83.5	8.2	42.7	73.3	145.1	4.3	25.8	8.5	7.1	17.2
Maize+Mungbean (1:1)	4.9	85.8	7.3	42.0	74.2	137.4	4.1	22.4	8.1	4.3	14.2
Maize+ Mungbean (2:2)	7.2	88.8	6.9	41.3	72.3	130.2	3.9	19.9	7.6	3.9	13.3
Maize+ Mungbean (3:3)	7.6	90.4	6.8	42.0	72.8	123.9	3.6	18.1	7.0	3.7	13.1
S.Em.±	0.4	0.6	0.1	0.5	0.4	0.8	0.1	0.7	0.3	0.3	0.4
C.D. (P=0.05)	1.5	2.1	0.3	NS	NS	2.7	0.2	2.3	0.6	1.1	1.5

Yield and yield attributes (branches per plant, pods per plant, grain yield per plant, grain and straw yield per hectare) of urdbean/mungbean: Analysis of values presented in Table 1b and 1c shows that, significantly highest branches per plant (4.0) was noticed in urdbean sole as compared to normal maize+urdbean (3.8) and paired maize+urdbean (3.6). However, lowest numbers of branches per plant were noticed under strip planted urdbean (3.4). Significantly, more number of branches per plant (4.3) were noticed under mungbean sole (4.3) which remained statistically on par with normal (1:1) maize+mungbean (4.1) than (2:2) paired maize+mungbean intercropped. However, minimum branches per plant (3.9) were found under strip planted maize+mungbean (3:3). This might be due to less space avail-

Table 2a: N, P, K content in grain and stover and qualities of maize as influenced by various treatments.

Treatment	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Protein content (%)	Protein yield (kg/ha)
	Grains	Stover	Grains	Stover	Grains	Stover		
Maize Sole	1.429	0.725	0.300	0.137	0.376	1.483	8.19	350.60
Maize+Urdbean (1:1)	1.440	0.729	0.301	0.146	0.378	1.542	8.33	365.80
Maize+ Mungbean (1:1)	1.433	0.732	0.307	0.148	0.382	1.529	8.24	358.64
Maize+ Urdbean (2:2)	1.441	0.741	3.330	0.147	0.386	1.547	8.26	370.20
Maize+Mungbean (2:2)	1.452	0.744	0.327	0.162	0.388	1.526	8.32	370.32
Maize+Urdbean (3:3)	1.571	0.747	0.371	0.159	0.389	1.527	9.00	410.33
Maize+Mungbean (3:3)	1.573	0.748	0.368	0.163	0.395	1.549	9.01	406.55
S.Em.±	0.077	0.002	0.023	0.006	0.009	0.020	0.42	18.90
C.D. (P=0.05)	NS	0.007	NS	NS	NS	NS	NS	41.55

Table 2b: N, P, K content in grain and stover and qualities of urdbean as influenced by various treatments.

Treatment	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Protein content (%)	Protein yield (kg/ha)
	Grains	Straw	Grains	Straw	Grains	Straw		
Urdbean Sole	3.447	1.559	0.692	0.292	0.743	1.710	21.55	173.70
Maize+ Urdbean (1:1)	3.427	1.652	0.689	0.261	0.710	1.690	21.41	98.12
Maize+ Urdbean (2:2)	3.316	1.685	0.636	0.279	0.643	1.677	22.60	99.52
Maize+Urdbean (3:3)	3.438	1.868	0.644	0.255	0.647	1.673	21.49	92.41
S.Em.±	0.073	0.037	0.016	0.018	0.032	0.034	0.46	6.89
C.D. (P=0.05)	NS	0.132	NS	NS	NS	NS	1.02	24.33

Table 2c: N, P, K content in grain and stover and qualities of mungbean as influenced by various treatments.

Treatment	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Protein content (%)	Protein yield (kg/ha)
	Grains	Straw	Grains	Straw	Grains	Straw		
Mungbean Sole	3.520	1.550	0.663	0.288	0.677	1.700	22.10	157.00
Maize+Mungbean (1:1)	3.541	1.620	0.669	0.258	0.640	1.650	22.13	96.22
Maize+ Mungbean (2:2)	3.644	1.667	0.631	0.273	0.647	1.660	22.80	88.51
Maize+ Mungbean (3:3)	3.744	1.840	0.623	0.253	0.643	1.640	23.40	85.80
S.Em.±	0.048	0.018	0.017	0.006	0.030	0.020	0.30	6.16
C.D. (P=0.05)	0.165	0.060	NS	0.022	NS	NS	1.03	21.71

able for urdbean/mungbean crop and more competition as compared to sole planting. Similar results were also reported by Upasani et al. (2000).

Significantly higher number of pods per plant were noticed under urdbean sole (30.2) as compared to other row ratios (Table 1b and 1c) which also differed significantly to each other. However, strip planted urdbean recorded the minimum pods per plant (24.4). Significantly more numbers of pods per plant were noticed under mungbean sole (25.8) as compared to other row ratios, i.e., 1:1 (22.4), 2:2 (19.9) and 3:3 (18.1). However, strip planting of maize + mungbean recorded the lowest number of pods per plant (18.1) which remained statistically on par with paired planting.

Significantly highest grain yield per plant (7.5 g) was observed in urdbean sole (Table 1b and 1c). Though, the difference between paired maize+urdbean (2:2) and strip maize+urdbean (3:3) was not significant. Among the different treatments, mungbean sole recorded significantly highest grain yield per plant (8.5g) which was on par with normal maize+mungbean (1:1) than paired planted maize+mungbean (7.6 g) which also remained on par with normal (8.1 g) and strip planted maize+mungbean (7.0 g). This might be due to poor translocation of photosynthates towards sink. Similar results were also reported by Upasani et al. (2000).

Significantly higher grain yield/ha was obtained under urdbean sole as compare to normal (1:1), paired (2:2) and strip (3:3) planted maize+urdbean (Table 1b and 1c). This treatment was also outyielded by 76.0, 84.1 and 84.4 per cent, respectively. However, the strip planted urdbean (3:3)

produces the lowest (4.3 q/ha) grain yield. The mungbean grown with different row ratios, remained on par to each other, significantly reduces the grain yield/ha than the mungbean sole (7.1q). However, the strip planted mungbean (3:3) resulted into the lowest grain yield (37q/ha) and the decrement was up to 3.4 q/ha. This increase might be due to the favourable source-sink relationship, less competition of light, and higher value of yield attributes which is the most important source that contributes to the development of sink and higher plant population at maturity. Similar findings were also reported by Shivay & Singh (2003).

The intercropping of urdbean with different row ratios significantly lowers down the straw yield of urdbean/ha, than its sole cropping (Table 1b and 1c). The reduction in the straw yield with normal, paired and strip cropping was to the tune of 17.8, 24.3 and 23.8 per cent, respectively. The straw yield/ha in mungbean follows the similar trend as the grain yield being highest in mungbean sole (17.2 q/ha). This increase was might be due to the better growth in terms of plant height, spared and dry matter accumulation (as the total dry matter accumulation per plant is the most important source that contributes to the development of sink) and higher plant population at maturity. Similar findings were also reported by Shivay & Singh (2003).

N, P and K content in grain and stover/straw and qualities (protein content and protein yield) of maize and urdbean/mungbean

***Nitrogen content in grains and stover/straw*:** Strip planted maize, which was on par with paired planted maize resulted into significantly higher nitrogen content in stover as compared to sole maize and normal (1:1) planted maize (Table 2a). Although, the highest nitrogen content in grains was recorded in strip planted maize+mungbean (3:3) but the differences were not significant. However, the sole maize grains had the lowest nitrogen content (1.429 per cent).

The nitrogen content in grains and straw varied from 447 to 3.738 and 1.559 to 1.868 per cent under paired and sole urdbean and urdbean sole and strip planted urdbean, respectively. However, the differences were statistically significant only in straw (Table 2b and 2c). The strip planted mungbean registered significantly highest nitrogen content in grains (3.744%) and straw (1.840%) as compared to mungbean sole and maize+mungbean normal (1:1) with the lowest values in mungbean sole. This reflected the beneficial effects of sole urdbean and mungbean which are directly related to root growth in terms of number and dry weight of root nodules per plant. These were in conformance to Dwivedi et al. (2012) and Dwivedi et al. (2015).

***Phosphorus contents in grains and stover/straw*:** The highest phosphorus content in grains and stover was recorded in strip planted maize+urdbean and maize+ mungbean (3:3), respectively (Table 2a). Though, the differences in grains and straw were found to be non significant. However, the lowest phosphorus content in grains and straw was found in sole maize (0.300 and 0.137 per cent, respectively). The content of phosphorus in grains and stover was higher due to more availability of these nutrients under balanced fertilization. Similar results were also reported by Singh et al. (2007).

The phosphorus content in grains and straw varied from 0.692 to 0.636 and 0.292 to 0.255 per cent under various intercropping systems, respectively. However, the differences were not statistically significant (Table 2b and 2c). The sole mungbean registered significantly higher phosphorus content in straw as compared to strip planted maize+mungbean (3:3) and with the lowest values of 0.253%. However, the phosphorus content in grains did not show any significant variation among various intercr-opping systems.

Potassium content in grains and stover/straw: The highest potassium content in grains and stover was recorded in strip planted maize+mungbean (3:3), though, the differences in grains and stover were found to be nonsignificant (Table 2a). However, the lowest potassium content in grains and stover was noted in maize sole (0.376 and 1.483 percent, respectively). The content of potassium in grains and stover was higher due to more availability of these nutrients under balanced fertilization. Similar results were also reported by Singh et al. (2007).

The potassium content in grains and straw varied from 0.743 to 0.643 and 1.710 to 1.673 in various treatments, respectively. However, the differences were not significant (Table 2b and 2c) in both. The potassium contents in grains and straw varied from 0.677 to 0.640 in sole mungbean and maize+mungbean (1:1) and 1.700 to 1.640 per cent under sole mungbean and strip planted mungbean (3:3), respectively.

Protein content and protein yield: Strip planted maize+ mungbean (3:3) intercropping system recorded the highest protein content (9.01%). However, the lowest protein content was noticed under sole maize but the difference was nonsignificant (Table 2a).

Significantly highest protein yield (410.33 kg/ha) of maize was registered under strip planted maize+urdbean (3:3), which remained on par with strip maize+mungbean (3:3) and paired maize+urdbean/mungbean (2:2) intercropping systems as compared to sole maize. Though, the lowest protein yield (350.60 kg/ha) was recorded in sole maize, but it did not show any significant difference with normal and paired planted maize with mungbean and urdbean. In intercropping system involving legume and non legume, legume may provide nitrogen benefiting non-leg-

ume component, which improve nitrogen content and protein yield (Dwivedi et al. 2015).

Significantly highest protein content was recorded under strip planted (3:3) urdbean, being on par with paired (2:2) planted urdbean than rest of the treatments. Although, the lowest protein content was noticed under urdbean sole (Table 2b and 2c). However, the significantly highest protein yield was observed under urdbean sole as compared to rest of the treatments. Although, the normal, paired and strip planted maize did not show any significant difference to each other. The increment in sole urdbean was to the tune of 88.0 per cent than strip planted urdbean. Whereas, in the regard of mungbean, significantly higher protein content in mung-bean was recorded under strip planted (3:3) mungbean than sole and normal (1:1) planted mungbean, although, the lowest protein content was observed under mungbean sole. The significantly highest protein yield (157.00 kg/ha) was produced under mungbean sole as compared to rest of the treatments. The lowest protein yield was obtained by strip planted mungbean (3:3), although, mungbean in different row ratio with regards to protein yield was alike. The increased protein content and protein yields in urdbean and mungbean sole was might be due to more nitrogen content in grains coupled with higher grain yield. The highest protein yield under this treatment was mainly due to more protein content in grains and high grain yield which in turn improved the protein yield. The increase in protein content of maize grains under intercropping with different geometries (Suresh et al. 2007, Dahmardeh et al. 2011) have also been reported earlier.

CONCLUSION

On the basis of experimental findings, it can be concluded that the strip planted maize+mungbean/urdbean (3:3) intercropping system proved to be better in growth and development, phenology nodulation, yield, nutrient dynamics and quality of crops. Besides, this treatment also maintains the soil fertility. Further, at least one more year research is needed to develop the module for maize+mung/urdbean intercropping system.

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