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Productivity, Uptake And Quality Of Maize-Soybean Intercropping As Influenced By Different Herbicides And Nitrogen Fertilization

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Abstract

The field experiment was conducted during Kharif seasons of 2009 and 2010 at Agricultural Research Farm, R.B.S. College, Bichpuri, Agra to study the effect of different herbicides and nitrogen levels on productivity, uptake and quality of maize-soybean intercropping system. The eight weed control treatments and four nitrogen levels were tested in split plot design. The significantly higher bio-mass, grain, stover, N content and their uptake by seed and stover of maize were obtained with Pendimethalin PE @ 1.5 kg ha^{-1} followed by Oxyfluorfen PE @ 0.15 kg ha^{-1}. The per cent increase in bio-mass, grain, stover, N content and their uptake by seed and stover by 120 kg N ha^{-1} over control were 96.7, 98.1, 95.9, 14.8, 29.6, 121.0 and 146.7, respectively. The application of Pendimethalin PE @ 1.5 kg ha^{-1} produced significantly higher bio-mass, grain and straw yields and N content and their uptake through seed and straw of soybean over rest of the weed control treatments except Oxyfluorfen PE @ 0.15 kg ha^{-1}. Application of 120 kg N ha^{-1} resulted in highest bio-mass, grain and straw yields and N content and their uptake through seed and straw but these were statistically at par with 40 and 80 kg N ha^{-1}. Significantly higher test weight protein content and protein production of maize was obtained with Pendimethalin PE @ 1.5 kg ha^{-1} followed by Oxyfluorfen PE @ 0.15 kg ha^{-1}. The test weight and protein production increased significantly with every increase in the levels of nitrogen up to 120 kg N kg^{-1}. The highest protein content was obtained with the application of 120 kg N ha^{-1} but this was statistically at par with 80 kg N ha^{-1}. The increase in test weight, protein and oil content and iodine value of oil, protein and oil production of soybean owing to Pendimethalin PE @ 1.5 kg ha^{-1} over weedy check was the tune of 13.4, 15.1, 11.6 7.1, 143.0 and 135.2%, respectively. The significantly lower oil content in seed as well as iodine value of oil was noted in 120 kg N ha^{-1} as compared to all other levels of nitrogen. Highest test weight protein content, protein and oil production of soybean were obtained with the application 120 kg N ha^{-1} but these were found statistically at par with 40 kg N ha^{-1} and 80 kg N ha^{-1}.

Key Words: Maize, Soybean, Herbicides, Yield, Nitrogen, Protein

Introduction

Maize crop regarded as a queen of cereals occupies a pride place among rainy season (kharif) crop in India. It is the principal crop of kharif season in northern hills of the country but plains of northern states like Uttar Pradesh, Rajasthan, Madhya Pradesh and Bihar also have sizeable acreage under this crop. Maize, a crop with high yield and market potential, fits well into rice-wheat systems by replacing rice (Paramesh et al., 2014). Compare to most cereals, maize faces interference of weeds to a greater degree, especially during the rainy season, which is the main growing period in north India. In the absence of appropriate weed management, yield loss may vary from 40-60% (Sunitha and Kalyani, 2012). Through farmers are in practice of doing some kind of physical operations to combat against weeds, incessant rains in prolonged spells, non availability of labour wages make the physical weeding non-feasible. Therefore, the only remedy left is to use herbicide at or immediately after sowing to insure weed suppression for 30-45 days (Choudhary et al., 2013). Regarding nutrient requirement, nitrogen is the most important for the growth and yield of maize. Ideal nitrogen management optimize grain yield, farm

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profit, and nitrogen use efficiency, while it minimizes the potential for leaching of nitrogen, thus preventing environmental pollution (Dar et al., 2014). The intercropping of cereals like maize, sorghum and pearlmillet in soybean is gaining lot of attention in recent years owing to their morphological differences and growing pattern. However, the nitrogen requirement of cereals being higher, the optimum doses need to be determined in the intercropping system keeping in view the nitrogen-sparing effect of the soybean acquired through biological nitrogen fixation (BNF). Thus there is a need to estimate the N requirement of cereals grown as intercrops in soybean (Layek et al., 2015).

Material and Methods

The field experiment was conducted during Kharif seasons of 2009 and 2010 at Agricultural Research Farm, R.B.S. College, Bichpuri, Agra, situated at 27^0 2' North latitude, 77^0 9' East longitude and altitude of 163.4 m above mean sea level. The average annual rainfall of the centre was 665 mm and most of which (84%) is contributed by south west monsoon during July to September. The experimental soil was sandy loam in texture containing organic carbon 0.38%, available N 189.7, P_2O_5 29.40 and K_2O 313.00 kg/ha with pH 8.6 and EC 1.65 dS/m at 25^0C. Thirty two treatment combinations comprising eight weed-control measures were applied (W_0-Weedy check, W_1-Hand weeding at 25 DAS, W_2-Oxyfluorfen PE @ 0.100 kg ha^{-1}, W_3-Oxyfluorfen PE @ 0.150 kg ha^{-1}, W_4-Pendimethalin PE @ 1.000 kg ha^{-1}, W_5-Pendimethalin PE @ 1.500 kg ha^{-1}, W_6- Metribuzin PE @ 0.500 kg ha^{-1} and W_7- Metribuzin PE @ 0.750 kg ha^{-1}) and four nitrogen levels (N_0, N_{40}, N_{80} and N_{120}) were tested in split plot design and replicated thrice with weed-control measures in main plot and levels of nitrogen in sub-plots. The crops were sown in the first week of July during 2009 and in second week of July during 2010. The maize variety 'Megha' and soybean variety PK 472 were used as base main and intercrop, respectively. The crop was fertilized with N as per treatment and Phosphorus (60 kg), Potash (40 kg) and Zinc (30 kg) ha^{-1} in all the treatments. Urea, Single super phosphate, Muriate of Potash and $ZnSO_4$ were used as the source of N, P_2O_5, K_2O and Zn, respectively. Half dose of N as per treatment and full dose of P_2O_5, K_2O and Zn were applied at the time of sowing as basal below the seed. The remaining half dose of N was top dressed at knee high stage of maize crop. Herbicides were sprayed as pre emergence by Knapsack sprayer fitted with flat pan nozzle using 500 litres of water ha^{-1}. The straw yield was computed by deducting the grain yield from the total biological yield. The N content in seed and straw/stover was estimated from the collected samples at harvesting as per the standard procedure (Prasad et al., 2006) and the protein content was computed using factor 6.25 multiplied by N content in seed. Similarly, the N uptake by maize/soybean was determined by multiplying dry-matter accumulation with their respective concentrations in grain and straw/stover. Iodine value of oil of soybean was determined by A.O.A.C., 1960.

Results and Discussion

Maize yield was significantly affected by different weed control measures (Table 1). Pendimethalin PE @ 1.5 kg ha^{-1} was significantly superior over all other weed control measures as regard of bio-mass production (100.6 q ha^{-1}) revealed the beneficial effect of less weed environment. The maximum grain production (38.9 q ha^{-1}) was obtained with Pendimethalin PE @ 1.5 kg ha^{-1} and this was significantly superior over rest of the weed control treatments. Uncontrolled weedy check caused 40% reduction in grain yield of maize compared to

Pendimethalin PE @ 1.5 kg ha^{-1}. While studying the physiological process underlying grain yield loss in maize due to weed competition, with the early-stage presence of weeds there was reduction in photo-synthetically active radiation, which accounted for reduced dry-matter accumulation by maize crop resulting in rapid decline in cobs number and weight that contributed in yield loss (Owla et al., 2015). Among the weed management practices, pre emergence application of Pendimethalin @ 1.5 kg ha^{-1} was found most effective in achieving significantly higher stover yield over all other treatments except Oxyfluorfen PE @ 0.15 kg ha^{-1} and also obtained higher stover yield by 40% over weedy check. On pooled basis, every increase in the level of nitrogen increased the bio-mass, grain and stover production significantly up to 120 kg N ha^{-1}. The per cent increase in bio-mass, grain and stover production by 120 kg N ha^{-1} over control were 96.7, 98.1 and 95.9, respectively. Higher fertility level of nitrogen (N_{120}) recorded higher values of light interception by mid canopy as compared to lower fertility levels. It may be attributed to higher LAI values with higher fertility levels. These results are conformity with that of Bahar and Singh (2013).

The data arrange in Table 1 revealed that the positive response of various herbicidal and hand weeding treatments on the yields of soybean. The maximum bio-mass production was found with pre emergence application of Pendimethalin @ 1.5 kg ha^{-1} and this was found significantly superior over all other treatments except Oxyfluorfen PE @ 0.150 kg ha^{-1}. The application of Pendimethalin PE @ 1.5 kg ha^{-1} produced the significantly higher grain yield as well as straw yield over rest of the weed control treatments but this treatment was failed to show its significant superiority over Oxyfluorfen PE @ 0.15 kg ha^{-1}. The increasing bio-mass, grain and straw yield with Pendimethalin PE @ 1.5 kg ha^{-1} was the tune of 70.1, 115.2 and 51.0 per cent, respectively over weedy check. The increase in seed yield with the application of Pendimethalin PE @ 1.5 kg ha^{-1} can be attributed to the fact that the crops were kept free of competition at the early critical stages of growth resulting in the crops using the nutrients and climatic resources more efficiently. These results are in confirmation with the findings of Yadav and Shaikh (2009). The highest bio-mass production (27.8 q ha^{-1}), seed yield (10.4 q ha^{-1}) and straw yield (17.4 q ha^{-1}) was were produced with the application of 120 kg N ha^{-1} but these were found statistically at par with 40 and 80 kg N ha^{-1}. It is obviously that dry matter is a net saving of photosynthets and essential for the building up of plant organs, which ultimately reflect on bio-mass and straw production. Hence, nitrogen is quite responsible for higher bio-mass, seed and straw production. Similar results have also been reported by Thenua et al. (2010).

N content and their uptake

It is evident from the Table 1 that weed control measures differed significantly in nitrogen content and their uptake. It is further noted that the application of Pendimethalin PE @ 1.5 kg ha^{-1} recorded the maximum nitrogen content in seed as well as stover of maize and this was closely followed by Oxyfluorfen PE @ 0.15 kg ha^{-1}. Pendimethalin PE @ 1.5 kg ha^{-1} was found significantly superior as compared to all other treatments except Oxyfluorfen PE @ 0.15 kg ha^{-1} in these respects. Amongst treatments, Pendimethalin PE @ 1.5 kg ha^{-1} gave significantly higher nitrogen uptake through seed (86.7 kg ha^{-1}) as compared to all the other treatments. The highest nitrogen uptake through stover (71.2 kg ha^{-1}) was obtained with the application of Pendimethalin PE @ 1.5 kg ha^{-1} (W_5) followed by Oxyfluorfen PE @ 0.15 kg ha^{-1}. Both treatments were found significantly superior as compared to all other treatments. Nutrient uptake is the function of the content and yield. Therefore, increase in grain and stover yields due to weed control can be reasoned for enhanced N uptake by the crop (Choudhary et al., 2013). Table further revealed that the nitrogen content in seed and stover increased significantly with every increase in the level of nitrogen up to 80 kg N ha^{-1}. However, the maximum nitrogen content in seed and stover were obtained with 120 kg N ha^{-1} but this was found statistically at par with 80 kg N ha^{-1}. The uptake of nitrogen through seed and stover increased significantly with every increase in the level of nitrogen up to 120 kg N ha^{-1}. This dose was found significantly superior as compared to all other levels of nitrogen. Verma (2011) also obtained that increase in nitrogen levels resulted increase in N uptake in maize.

The significantly higher nitrogen content and their uptake were noted in all the treated plots as compared to weedy check in soybean crop. Among all the weed control measures, highest nitrogen content in seed was observed with Pendimethalin PE @ 1.5 kg ha^{-1} and this treatment was significantly superior as compared to all other treatments except Oxyfluorfen PE @ 0.15 kg ha^{-1} but Pendimethalin PE @ 1.5 kg ha^{-1} was proved its significant superiority over Metribuzin PE @ 0.5 kg ha^{-1} and Metribuzin PE @ 0.75 kg ha^{-1} with regard of N content in straw. However, application of Pendimethalin PE @ 1.5 kg ha^{-1} resulted in significantly higher nitrogen uptake by seed as well as straw but this treatment was statistically at par with Oxyfluorfen PE @ 0.15 kg ha^{-1}. The increasing in uptake of N through seed and straw with Pendimethalin PE @ 1.5 kg ha^{-1} was the tune of 142.2 and 114.5 per cent, respectively over weedy check. These variations were evident from the fact that the weeds removed large quantity of nutrients under unweeded control, while other weed control measures, the nutrients available in soil were effectively utilized by crop plant for growth and development. Therefore, controlling weeds not only helped in improving yield but also nutrients uptake by increasing nutrients concentration in seed and straw of soybean (Monsefi et al., 2013). Nitrogen content and their uptake through seed and straw increased significantly with the application of 40 kg N ha^{-1} as compared to control. Although the highest nitrogen content and their uptake through seed and straw were obtained with the application of 120 kg N ha^{-1} but this was found statistically at par with 40 and 80 kg N ha^{-1}. This trend of response perhaps indicates that with increased supply of nitrogen, plants improve vegetative growth and thus absorb and utilize more of nitrogen. Increased uptake and higher percentage of nitrogen in plant with the liberal use of nitrogen have also been reported by Munirathnam and Kumar (2010).

Quality characters

Reference to Table 2 clearly indicated that the test weight of maize was obtained significantly higher (225.2 g) with the application of Pendimethalin PE @ 1.5 kg ha^{-1} as compared to all other treatments and also was 77.5% higher than that of weedy check. Pre-emergence application of Pendimethalin @ 1.5 kg ha^{-1} recorded the significantly higher protein content in seed compared to other weed control measures except Oxyfluorfen PE @ 0.15 kg ha^{-1}. It may increase the absorption and assimilation of N by plant and encouraged the translocation of N from vegetative to grain which might indirectly affect protein concentration (Parames et al., 2013). The test weight increased significantly with every increase in the levels of nitrogen up to 120 kg N kg^{-1}. Although the highest protein content was obtained with the application of 120 kg N ha^{-1} but this was statistically at par with 80 kg N ha^{-1}. Similar results have also been reported by Kumar and Dhar (2010).With regard to test weight and protein content in seed of soybean, it was found that significantly higher test weight (123.2 g) and protein content (38.2%) were obtained by Pendimethalin PE @ 1.5 kg ha^{-1} but this treatment was failed to its superiority against Oxyfluorfen PE @ 0.15 kg ha^{-1} in these respects. The better protein content in soybean crop as a result of weed control measures could be attributed to better nitrogen content under these treatments favoured by effective control of weeds. Presence of weeds throughout the growing season in weedy check plot was instrumental in reduced protein content in this plot (Peer et al., 2013). The highest oil content in seed as well as iodine value of oil was recorded with Pendimethalin PE @ 1.5 kg ha^{-1} followed by Oxyfluorfen PE @ 0.15 kg ha^{-1}. Both these treatments were significantly superior as compared to all other treatments expect Pendimethalin PE @ 1.0 kg ha^{-1}. Enhancement in the oil content of soybean as affected by various weed control measures may be attributed to better nutrition of the soybean which plays a vital role in improving oil value of soybean (Peer et al., 2013). Test weight and protein content in seed increased significantly with the application of 40 kg N ha^{-1} as compared to control. Although the highest test weight and protein content were obtained with the application 120 kg N ha^{-1} but these were found statistically at par with 40 kg N ha^{-1} and 80 kg N ha^{-1}. Oil content in seed and iodine value of the oil decreased with every increase in nitrogen level, there was corresponding reduction in these regard. The significantly lower oil content in seed as well as iodine value of oil was noted in 120 kg N ha^{-1} as compared to all other levels of nitrogen. The reduction in seed, oil percentage with the increase of N fertilizer may be due to the dilution effect of increased seed yield with increased N fertilization and the inverse relationship of protein and oil content (Samir et al., 2015).

Protein and oil Production. There was observed significant difference in protein and oil production due to weed control measures over weedy check. Maize crop treated with Pendimethalin PE @ 1.5 kg ha^{-1} produced significantly higher protein as compared to all other treatments and this treatment also produced more protein of 47.3% over Metribuzin PE @ 0.5 kg ha^{-1}. The protein production increased significantly with every increase in the levels of nitrogen up to 120 kg N kg^{-1}. Since, nitrogen is the constituent of protein and also responsible for improvement in grain, this may be the reason for higher protein content under the nitrogen applied conditions (Munirathnam and Kumar, 2010). The protein as well as oil production by soybean crop were significantly higher (458.8 and 242.1 kg ha^{-1}) with the application of Pendimethalin PE @ 1.5 kg ha^{-1} but this treatment was statistically at par with Oxyfluorfen PE @ 0.15 kg ha^{-1}. The increase in protein and oil production owing to Pendimethalin PE @ 1.5 kg ha^{-1} over weedy check was the tune of 143.0 and 135.2%, respectively. The protein and oil production increased significantly with the application of 40 kg N ha^{-1} as compared to control. Although the highest protein and oil production were produced with the application of 120 kg N ha^{-1} but this was found statistically at par with 40 kg N ha^{-1} and 80 kg N ha^{-1}. Hence, a reverse trend was observed between oil content and oil yield with levels of nitrogen. The decrease in oil content with an increase in nitrogen levels might be due to utilization of carbohydrates in protein formation and thereby leaving less carbohydrate for oil biosynthesis, while the increased seed yield with increasing nitrogen levels is responsible for producing higher oil yield (Thenua et al., 2010).

It was concluded that among the weed control treatments, pre emergence application of Pendimethalin @ 1.5 kg ha^{-1} was superior for improving yield, uptake of N and quality. The fertilization of N with 120 kg N ha^{-1} for maize and 40 kg N ha^{-1} for soybean enriched the yield, uptake of N and quality of soybean.

Table.1 Yield, N content and their uptake of maize and soybean as affected by weed control measures and nitrogen levels (pooled data of two years)

Treatments	Yield						Nitrogen content and their uptake							
	Maize			Soybean			Maize				Soybean			
	Biolo-gical yield (q/ha)	Grain yield (q/ha)	Stover yield (q/ha)	Biolo-gical yield (q/ha)	Grain yield (q/ha)	Straw yield (q/ha)	N content (%) in seed	N content (%) in stover	N uptake through seed (kg/ha)	N uptake through stover (kg/ha)	N content (%) in seed	N content (%) in straw	N uptake through seed (kg/ha)	N uptake through straw (kg/ha)
Weed control measures														
Weedy check	78.8	27.8	51.0	17.8	05.7	12.1	1.84	0.78	51.4	42.8	5.32	0.45	30.3	05.5
Hand weeding at 25 DAS	93.0	34.3	58.7	22.7	08.0	14.7	1.92	0.94	66.0	56.7	5.72	0.58	45.6	08.6
Oxyfluorfen PE @ 0.100 kg ha^{-1}	94.8	35.3	59.5	23.5	08.4	15.1	2.05	0.98	72.6	60.0	5.79	0.60	48.7	09.0
Oxyfluorfen PE @ 0.150 kg ha^{-1}	99.3	37.8	61.5	30.0	11.8	18.2	2.18	1.07	81.3	67.4	6.06	0.63	71.8	11.4
Pendimethalin PE @ 1.000 kg ha^{-1}	97.7	36.9	60.8	26.8	10.1	16.7	2.09	1.01	77.2	62.9	5.98	0.61	60.4	10.2
Pendimethalin PE @ 1.500 kg ha^{-1}	100.6	38.9	61.7	30.3	12.0	18.3	2.22	1.13	86.7	71.2	6.12	0.65	73.4	11.8
Metribuzin PE @ 0.500 kg ha^{-1}	87.0	31.2	55.8	22.4	07.8	14.6	1.87	0.85	58.5	49.7	5.56	0.55	43.0	08.0
Metribuzin PE @ 0.750 kg ha^{-1}	89.3	32.3	57.0	22.6	07.9	14.7	1.89	0.89	61.4	52.3	5.62	0.57	44.5	08.3
SEm±	0.60	0.50	0.22	0.24	0.10	0.09	0.04	0.03	1.40	1.46	0.04	0.02	0.71	0.15
CD (P=0.05)	1.28	1.07	0.47	0.73	0.30	0.27	0.12	0.10	4.25	4.40	0.13	0.07	2.14	0.46
Nitrogen levels														
N_0	58.3	21.5	36.8	15.0	04.8	10.2	1.84	0.81	40.0	30.6	5.60	0.48	27.1	04.8
N_{40}	90.6	33.6	57.0	27.6	10.3	17.3	2.00	0.95	67.6	56.2	5.78	0.59	59.3	10.2
N_{80}	106.6	39.5	67.1	27.7	10.4	17.3	2.07	1.03	81.5	69.1	5.83	0.62	60.3	10.7
N_{120}	114.7	42.6	72.1	27.8	10.4	17.4	2.11	1.05	88.4	75.5	5.86	0.64	61.0	11.0
SEm±	0.37	0.33	0.13	0.12	0.05	0.06	0.03	0.02	0.91	1.04	0.03	0.02	0.60	0.29
CD (P=0.05)	1.13	0.94	0.42	0.35	0.17	0.19	0.08	0.06	2.73	3.09	0.09	0.06	1.79	0.85

Table.2 Qualitative characters and protein production of maize and soybean and oil production by soybean as affected by weed control measures and nitrogen levels (pooled data of two years)

Treatments	Qualitative characters						Protein production (kg ha^{-1})		Oil production by soybean (kg ha^{-1})
	Maize		Soybean						
	Test weight (g)	Protein content in seed (%)	Test weight (g)	Protein content in seed (%)	Oil content in seed (%)	Iodine value of oil	Maize	Soybean	
Weed control measures									
Weedy check	209.0	11.8	108.6	33.2	18.1	126.80	327.9	188.8	102.9
Hand weeding at 25 DAS	217.1	12.3	115.2	35.8	19.4	132.4	421.9	285.1	154.3
Oxyfluorfen PE @ 0.100 kg ha^{-1}	218.4	13.1	116.4	36.2	19.5	133.1	458.5	304.4	163.2
Oxyfluorfen PE @ 0.150 kg ha^{-1}	223.1	13.8	122.5	37.9	20.0	135.5	525.5	448.5	235.9
Pendimethalin PE@ 1.000 kg ha^{-1}	219.9	13.3	119.6	37.3	19.9	135.2	492.4	377.1	198.9
Pendimethalin PE@ 1.500 kg ha^{-1}	225.2	14.1	123.2	38.2	20.2	135.8	552.1	458.8	242.1
Metribuzin PE @ 0.500 kg ha^{-1}	212.6	12.0	112.4	34.8	19.1	127.4	374.7	269.1	147.8
Metribuzin PE @ 0.750 kg ha^{-1}	214.1	12.1	113.4	35.1	19.2	128.0	392.5	278.1	152.3
SEm±	0.62	0.11	0.40	0.29	0.08	0.11	06.01	05.14	06.55
CD (P=0.05)	1.85	0.32	1.18	0.85	0.22	0.34	17.98	15.35	19.70
Nitrogen levels									
N_0	208.8	11.9	109.7	33.4	19.5	133.5	252.8	161.6	94.4
N_{40}	216.9	12.8	118.1	36.6	19.4	132.9	430.0	375.4	198.7
N_{80}	220.9	13.2	118.8	37.0	19.3	130.8	521.6	383.1	199.8
N_{120}	223.0	13.4	119.1	37.2	19.2	129.9	568.4	387.2	200.3
SEm±	0.55	0.06	0.35	0.25	0.03	0.09	05.26	04.61	01.02
CD (P=0.05)	1.63	0.19	1.04	0.74	0.08	0.28	15.70	13.80	03.03

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