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ECONOMICS OF RICE-FISH CULTURE IN WET LAND RICE ECOSYSTEMS

M. HAZRAT ALI[1] AND LUN G. MATEO[2]

ABSTRACT

The study was conducted at the Central Experimental Station, Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines during dry season to assess the economic performance of different treatments with various depth of water in rice-fish culture in wet land rice ecosystems. The additional cost incurred ranging from 106.86 to 112.47 % was due to excavation of pond refuge, making dikes, installation of net screen, fingerlings and supplementary fish feed. Despite such higher costs, all treatments with rice-fish produced higher net return than rice monoculture. The highest total return (P 94449.0/ha = U$ 2099/ha), gross margin (P88449.00 = U$ 1965.53) and net income (P 38630.41/ha = U$ 858/ha) were obtained from rice-fish culture at 11-15 cm depth of water which were statistically identical with total return and net come from rice-fish at 16-20 and 21-25 cm depths of water. Though the results showed an increasing net income from 5 to 34.61%, but the highest increase (34.61%) in net income was from 11-15 cm water depth.

Key words: Rice-fish culture and economic analysis

INTRODUCTION

Rice-Fish culture produces more income than rice monoculture. The profitability of rice-fish culture has been reported higher than rice monoculture (Ahmed, *et al*., 1992; Sevellija, 1992). The rate of returns ranged from 27-45 % (PCAMRD and PCARRD, 1990). The system needs more working capital due to fingerlings, fish feed, raising dikes and pond refuge costs. Despite higher cost

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involvement many countries in Asia have adopted the systems. Literature suggested that in the Philippines, integration of rice-fish culture had been incidental as rice was first grown in water-field environments. According to Campos (1985), the scientific integration of rice-fish culture in the Philippines started in 1974. The government started the pilot production program with 2,294 farms in 1997 (Dela Cruz, et al., 1990) and the program covered 1,397 ha in 1982 (Sevelleja, 1992). Potential area of rice-fish culture in the Philippines was estimated at about 2.7 M ha (Phil Rice, 2001)

So far information available on economics of rice-fish culture is insufficient. The reasons may be as (i) the practice is not yet commercialized; (ii) fish culture in rice fields is still largely a small scale or backyard type operation where the produce, especially fish is usually consumed by the farmer households. According to Tagarino (1985) about 80% of the total fish production in rice fields is consumed by the farm family.

However, before any new system or technology is recommended for farmers, its costs and benefits should be assessed (Gittinger, 1982). Therefore, the present study was undertaken to determine the economic performance of various treatments with different water depths in rice-fish culture under wetland rice ecosystems. “Costs and returns analysis” were made to provide a basis for adoption or rejection of the technology by the farmers.

MATERIALS AND METHOD

The experiment was conducted at the Central Experimental Station, Philippine Rice Research Institute, during dry season of 2001. The soil of the experimental field was Maligaya clay loam. The sizes of the experimental plots were 11.6 m long and 10.6 m wide. The experimental plots were laid out in Randomized Complete Block Design having 5 treatments with 3 replications. The experiment was conducted with the treatments: (i) T1= Rice alone at 5-10 cm water depth (Control), (ii) T2= Rice-fish at 5-10 cm water depth, (iii) T3= Rice-fish at 11-15 cm water depth, (iv) T4= Rice-fish at 16-20 cm water depth and (v) T5= Rice-fish at 21-25 cm water depth.

Dikes with base width of 50 cm, top width of 30-40 cm and height of 40-50 cm were constructed in each plot to supply adequate water for each treatment. A pond refuge covering 10 % of total land area of each plot having 1 m deep was excavated and connected with one end of all rice plots, except the control plot. Each of the plots (except control) was provided with separate screen for water inlets and outlets. PSB (Philippine Seed Board) Rc. 66, a high yielding lowland rice variety was transplanted with twenty-nine old day seedlings using 2 seedlings/hill. Conventional methods of cultural practices were made.

Water depth of 3-5 cm was maintained during first week of transplanting and increased as required by the treatments when fingerlings were released. Water level

was monitored everyday and irrigation made to maintain the stated water depth for the treatments.

Fingerlings of Nile tilapia (*Orechromis niloticus*) or GIFT (Genetically Improved Farmed Tilapia) were released @10,000/ha at 11 days after rice transplanting (DAT). Supplementary feed was applied two times in a day (½ at 7-8 a.m. and ½ at 4-5 p.m.) based on 10 % of fish body weight. Fish was reared for 79 days. Water was drained out just before the fish harvest. Rice was also harvested at the same day of fish harvest.

RESULTS AND DISCUSSION

A simple costs and returns analysis was used to compare the profitability of production systems. The values of input and output items were computed for considering the existing prices of local market. The total returns of the production systems were from rice and fish biomass (Table 2). Total cost was P 26741.64/ha (U$594) for conventional monoculture rice farming. All treatments with rice-fish culture incurred higher production costs. The highest cost of P 56818.59/ha (U$ 1263) was observed from rice + fish culture with 21-25 cm depth of water (Table 1). The higher costs was involved in rice-fish farming was due to the additional expenditures for the excavation of pond refuge, making dikes, installation of net screen, cost of fingerlings, and supplementary fish feed. The additional costs of these items ranged from 106.86-112.47 %.

Table 1. Costs (peso/ha/crop) of different treatments in rice-fish culture during dry season, Philippines, 2001(Values are extrapolated from 123 m^2 experimental plot)

Parameters	Treatments				
	Rice alone at 5-10 cm water depth	**Rice + fish at 5-10 cm water depth**	**Rice + fish at 11-15 cm water depth**	**Rice + fish at 16-20 cm water depth**	**Rice + fish at 21-25 cm water depth**
Costs of production (P/ha)					
Rice seed (20 kg) @ P 30/kg	600.00	600.00	600.00	600.00	600.00
Land preparation	4000.00	4000.00	4000.00	4000.00	4000.00
Excavation of pond & dikes	-	9100.81	9100.81	9100.81	9100.81
Net screen	-	1773.17	1773.17	1773.17	1773.17
Seedling pulling	500.00	500.00	500.00	500.00	500.00
Transplanting	4500.00	4500.00	4500.00	4500.00	4500.00
Fertilizer	4021.64	4021.64	4021.64	4021.64	4021.64

Parameters	Treatments				
	Rice alone at 5-10 cm water depth	**Rice + fish at 5-10 cm water depth**	**Rice + fish at 11-15 cm water depth**	**Rice + fish at 16-20 cm water depth**	**Rice + fish at 21-25 cm water depth**
Land rental	6000.00	6000.00	6000.00	6000.00	6000.00
Fingerlings	-	7500.00	7500.00	7500.00	7500.00
Fish feed	-	8441.46	8441.46	8441.46	8441.46
Harvesting and threshing of rice	6120.00	6120.00	6120.00	6120.00	6120.00
Harvesting of fish	-	1761.51	1761.51	1761.51	1761.51
Total (P/ha)	**26741.64**	**55318.59**	**55818.59**	**56318.59**	**56818.59**

Labor wage= P 130/ man day, Price: Rice bran=P 5/kg, Commercial feed=P 17/kg, Fertilizers (Urea=P 9/kg, Ammonium phosphate=P 8.5/kg, Muriate of potash=P 9/kg

Total return was P 55440/ha (U$ 1232) from rice monoculture but the highest was P 94449.0/ha (U$ 2099) from rice + fish at 11-15 cm depth of water (Table 2). The treatment with rice + fish at 11-15 cm depth of water also produced the highest gross margin (P88449.00 = U$ 1965.53) and net income (P38630.41/ha = U$ 458). Results of net income revealed significant difference ($P< 0.05$) among the treatments, but it was the same when the production system was maintained at 11-15 cm depth of water and above (Table 3).

Table 2. Sources and returns from different treatments in the production system, dry season, Philippines, 2001

Items	Treatments				
	Rice alone at 5-10 cm water depth	**Rice + fish at 5-10 cm water depth**	**Rice + fish at 11-15 cm water depth**	**Rice + fish at 16-20 cm water depth**	**Rice + fish at 21-25 cm water depth**
Sources					
Rice grain yield (kg/ha)	6930.00	6694.00	6954.0	6844.00	6240.00
Fish biomass (kg/ha)	-	708.94	862.60	816.26	909.76
Returns					
Rice alone (P/ha)	55440.00	53552.00	55632.00	54752.00	49920.00
Fish alone (P/ha)	-	31902.30	38817.00	36731.70	40939.20
Rice+ Fish (P/ha)	**55440.00** (U$ 1232)	**85454.30** (U$ 1899)	**94449.00** (U$ 2099)	**91483.70** (U$ 2033)	**90859.20** (U$ 2019)

Estimated prices: Rice = P 8/ha, Fish = P 45/kg; Conversion rate: 1U$=P45

Table 3. Economic performance of different treatments with various water depths in rice-fish culture system, dry season, 2001

Treatments	Total Cost (P/ha)	Total Return (P/ha) [1]	Gross margin (P/ha)	Net Income (P/ha) [2]	Income Increase (%)	B/C Ratio
Rice alone at 5-10 cm water depth (Control)	26741.64	55440.00 c	49440.0	28698.36 b	-	2.07
Rice + fish at 5-10 cm water depth	55318.59	85454.30 b	79454.3	30135.71 b	5.00	1.54
Rice + fish at 11-15 cm water depth	55818.59	94449.00 a	88449.0	38630.41 a	34.61	1.69
Rice + fish at 16-20 cm water depth	56318.59	91483.70 ab	85483.7	35165.11 ab	22.53	1.62
Rice + fish at 21-25 cm water depth	56818.59	90859.20 a	84859.2	34040.61 ab	18.62	1.60
CV (%)	-	4.2	-	10.5	-	-

Means followed by a common letter are not significantly different at 5% level by DMRT.

[1] Significant at 1% level

[2] Significant at 5% level

Results also indicated that the change in production system caused a change in net income. Net income increased from 5 to 34.61%. The highest increase in net income (34.61%) was observed in the treatment with rice + fish at 11-15 cm depth of water. Earlier, Sevilleja (1978) also observed an increased income (40%) from rice-fish compared to rice, alone which was almost identical to the results of the present study. In China, rice-fish farming attained an increase in net income (45%); in the Philippines (40%) and in Vietnum (69%) (Demaine and Halwart, 2001). Fujisaka and Vejpas (1990) reported rice-fish culture could be earning 65% higher average net return than rice monoculture. Benefit cost ratio (B/C ratio) for all the treatments with fish was above 1.50 (Table 3), which suggested that, the economic viability of the production system. Gittinger (1982) suggested if B/C ratio is more than 1.00 the technology could be sustainable.

The rice plot where fish was introduced the gross yield reduced because 10 % of the land was used for pond refuge. However, this yield loss was compensated by increase of rice yield due to integration of rice and fish particularly at 11-15 cm depth of water. The other treatments with fish produced just below the reduction levels (Table 2). But all the treatments with fish produced higher net income than rice monoculture indicating a big contribution of fish in the production system.

The results of the present study suggested that total rice yield per plot decreased because of 10% land was used for excavation of pond refuge. Despite the reduction of gross rice yield the economic analysis suggested that the integration of fish in rice systems irrespective of treatments produced higher economic benefit than the conventional rice monoculture. This would contribute better livelihood of rice farmers in the Philippines and in other rice growing countries.

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EFFECT OF FEMALE MALE RATIO AND HARVESTING STAGE ON YIELD AND QUALITY OF POINTED GOURD (*Trichosanthes dioica* Roxb.)

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ABSTRACT

The experiment was conducted at the Regional Agricultural Research Station, Ishurdi, Pabna during the growing season 2004-2005 to find out the effect of optimum female male ratio and appropriate harvesting stage of pointed gourd on yield and quality. The studies were on three female male ratio viz; 15:1 (T_1), 10:1 (T_2) and 5:1 (T_3) and three harvesting stages viz. 8, 12 and 16 days after female flower anthesis. The highest yield (31.0 t/ha) was obtained from 15:1 female male ratio (T_1). It was also observed that at 12 days after female flower anthesis (S_2) the plant produced the highest yield 31.06 t/ha. The lowest yield (18.77 t/ha) was recorded from 5:1 female male ratio with harvesting stage at 8 days after female flower anthesis (S_1T_1). The result showed that combination S_2T_1 (15:1 plant density with harvest at 12 days) was found better yield.

Key words: Female male ratio, Harvesting stage, Yield, Quality and Pointed gourd

INTRODUCTION

Pointed gourd (*Trichosanthes dioica Roxb.*) is a tropical cucurbit vegetable crop. Bengal-Assam is the primary centre of origin (Choudhury, 1990). It is widely cultivated in Bangladesh and known by the name of Parwal, Palwal or Parmal in different parts of India and Bangladesh. In recent year, its area under cultivation has gone up to 85,425 hectares with a total production of 223000 metric ton (BBS. 2005).

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It is rich in vitamin and minerals containing 9.0 mg Mg, 2. 6 mg Na, 83.0 mg K, 1.1 mg Cu and 17.0 mg S per 100 g edible part (Singh, 1989).

In Bangladesh yield of pointed gourd is very low compared to other pointed gourd producing country like India (7.5 - 8.0t/ha). Seshardi (1986) stated that pointed gourd as dioecious plant produce staminate and pistillate flowers in different plants. Farmers usually do not keep any male plant in the field. Without male plant pollination and fertilization are hampered. Without fertilization fruits drop before attaining mature stage. The pointed gourd farmers think that the presence of male plants in the field is just waste of land. But they do not understand the need for male plants in the field for pollination, fertilization, fruit setting and yield. Farmers do not know about male-female plant ratio for successful pollination and fertilization of female flower. Plant sex density (female: male) is therefore, a very important factor for fruit setting and achieving higher yield. Moreover, harvesting stage of fruit is also important criteria for quality production. Fruit grew larger and heavier due to delayed harvesting as reported by Maity *et al*. (1995). If harvesting is delayed, the seeds become hard and the vegetables less desirable for customers (Singh and Whithead, 1999). So far no work has been done for the male-female ratio and stage of proper harvest time in Bangladesh. So, the present study was undertaken to find out the plant sex density (female male ratio) and appropriate stage of fruit harvest for higher yield and better quality of pointed gourd.

MATERIALS AND METHOD

The study was undertaken at the Regional Agricultural Research Station, Ishurdi, Pabna during the period from 2005-06. The experiment was laid out in a factorial RCB design with three replications. Three different plant sex density (Female: male) viz., (i) 15:1, (ii) 10:1 (iii) 5:1 and three harvesting stages viz., (i) harvesting at 8 days after female flower anthesis (ii) harvesting at 12 days after female flower anthesis and (iii) harvesting at 16 days after female flower anthesis were included in the study. The male plant was planted in the middle of the bed. The anthesis of female flower was determined when the female flower was opened. The mean annual rainfall was 1775 mm. The warmest and coldest months are June (36^0C max.) and January (10.3^0C min.) (Ara, 2001). The soil of the experiment was clay loam in texture belonging to the high Ganges River flood plain under AEZ 11 (FAO, 1971). The selected plot was well drained having pH value 8.5. The bed size was 3.0m x 1.5m, spacing was 1.5m x 1.0m and pit was 50 cm x 50 cm x 30 cm. The vine was planted on 10^{th} November 2005. BARI patal-2 (PG0025) was used as a planting material. Manures and fertilizers were applied as per recommendation (Rashid,

1993). The N, P_20_5 and K_20 were applied in the form of urea, triple super phosphate (TSP) and Muriate of potash (MP) at the rate of 62.10 kg N, 80.40 kg P_20_5, 60.00 kg k_20 per hectare. The cowdung was applied at the rate of 10 tons per hectare. The entire quantity of cowdung, and TSP were applied at final land preparation. Urea and MP were applied as top dressing in three equal installments at 20, 60 and 90 days after sowing. The pointed gourd field was mulched with rice straw. Irrigation and other intercultural operations were done as and when necessary. Data on first flowering, vine length at first female flowering, number of node at 1st female flowering, number of shoots per plant, number of fruits per plant, single fruit weight, weight of fruit per plant, fruit length, fruit radius, pulp weight per fruit, number of seeds per fruit, weight of seeds per fruit yield ton per hectare were recorded. The significance of difference between treatments was evaluated by the least significance difference (LSD) test for interpretation of results (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of plant sex density (female male ratio):

The results on the effect of plant sex density (female male ratio) and harvesting stage on yield and quality of pointed gourd is presented in Tables 1 and 2.

Table 1. Effect of plant sex density on yield and quality of pointed gourd

Treatment (female – male ratio)	Days to 1st flowering	Vine length at 1st female flowering (cm)	No. of node at 1st female flowering	No. of shoot /plant	No. of fruit/ plant	Single fruit wt. (g)	Weight of fruit /plant (kg)	Fruit length (cm)	Fruit radius (cm)	Pulp wt (g)	No. of seed /fruit	Wt. of seed/ fruit (g)
15:1(T_1)	123.9b	136.88	10.8	3.0	162.1a	37.3a	5.0a	8.6a	3.43a	33.0a	18.0	3.30
10:1(T_2)	109.8c	151.11	11.3	3.0	148.3b	33.17b	4.27b	7.80b	3.19b	31.1b	16.78	3.22
5:1(T_3)	128.4a	146.11	10.8	3.2	142.4c	29.11c	3.67c	7.35c	3.07c	32.0ab	17.0	3.29
CV(%)	1.76	9.74	9.77	20.53	1.83	5.55	5.61	3.29	2.80	4.65	12.03	7.78

In column, similar letter(s) do not differ significantly at 5% level of significance

Table 2. Effect of harvesting stage on yield and quality of pointed gourd

Treatment (days after female flower an thesis)	Days to 1st flowering	Vine length at 1st female flowering (cm)	No. of node at 1st female flowering	No. of shoot /plant	No. of fruit/ plant	Single fruit wt. (g)	Weight of fruit /plant (Kg)	Fruit length (cm)	Fruit radius (cm)	Pulp weight /fruit (g)	No. of seed /fruit	Weight of seed/ fruit (g)
S_1 (8 days)	119.8	126.1b	10.56	3.2	149.7b	24.2c	3.29b	6.81c	2.84b	17.9c	15.3b	1.2c
S_2 (12 days)	121.3	142.4ab	11.89	3.1	152.6a	35.4b	4.66a	7.27ab	3.40a	37.7b	18.1a	3.7b
S_3 (16 days)	121.0	165.6a	10.67	2.8	150.7ab	39.94a	4.60a	9.70a	3.46a	40.4a	18.6a	4.8a
CV (%)	1.76	9.74	9.77	20.53	1.83	5.55	5.61	3.29	2.80	4.65	12.03	7.78

In column, similar letter(s) do not differ significantly at 5% level of significance.

Effect of plant sex density on yield and quality:

Days to 1st flowering: Days to 1st flowering was earlier (109.8 days) in 10:1 plant sex density and late (128.4 days) in 5:1 plant sex density. Shanmugavelu (1989) reported that pointed gourd took 136 to 158 days for first flowering after planting.

Vine length: The highest vine length (151.11cm) at 1st female flowering was obtained in 10:1 plant sex density (female: male) and the lowest vine length (136.88cm) was observed in T_1 (15:1) but significant difference was not found.

Number of node: Maximum number of node (11.3) at 1st female flowering was found in 10:1 plant sex density. The node at which first flower appears is an important character that determine the earliness of flowering. This is in agreement with the finding of Pathak and Singh (1950). Prasad and Singh (1990) reported that in pointed gourd the first female flower appear on 5th to 18th node.

Number of shoot per plant: The highest number of shoot per plant (3.2) was obtained from 5:1 plant sex density (Female: male) but at par to other treatments. Number of shoots per plant is an important character that plays a vital role in yield of many crops particularly in those which bear fruits in the leaf axils. In case of pointed gourd, flower and fruits are borne in leaf axils of shoot. The higher was the number of branches per plant the higher was the number flowers and fruits. Number of shoots at first flowers varied among the treatments.

Number of fruit per plant: The highest number of fruit per plant (162.1) was obtained from T_1 (15:1 female and male ratio) and lowest number (142.4) from T_3 (5:1 female male ratio). This result has the same trend with findings of Singh and

Whithead (1999). Prasad and Singh (1990) also observed significant variation of pointed gourd per plant.

Single fruit weight: Fruit weight varied significantly among the treatments and ranged from 29.11 g to 37.3g. Significantly highest single fruit weight (37.3g) was obtained in T_1 (15:1 ratio) and lowest fruit weight (29.1g) in T_3 (5:1 ratio). The variation of fruit weight could be due to the genetical, physiological, nutritional or environmental influence.

Weight of fruit per plant: Weight of fruit per plant varied significantly among the treatment and ranged from 3.67 kg to 5.0 kg. The highest weight of fruits per plant (5.0kg) was obtained in T_3 (15:1 female male ratio). This result is in agreement with the findings of Singh and Whithead (1999). The lowest weight of fruits (3.67 kg) per plant was obtained from T_3 (5:1 female male ratio).

Fruit length: Length of fruit varied significantly among the treatments and ranged from 7.35 cm to 8.60 cm. Longest fruit (8.60cm) was obtained from T_3 (15:1 female male ratio), which was significantly different from other treatments. The shortest fruit (7.35) was recorded in T_3 (5:1 female male ratio). The results on fruit-length were similar with findings of Prasad and Singh (1990).

Fruit radius: The radius of fruit ranged from 3.07cm to 3.43cm and varied significantly among the treatments (T_1:T_2:T_3). The maximum and the minimum fruit radius were recorded in T_3 (15:1) and T_1 (5:1) respectively.

Pulp weight per fruit: Pulp weight is another important character of quality in pointed gourd. Pulp weight varied significantly among the treatments and ranged from 31.1g to 33.0g. The maximum pulp weight (33.0g) was obtained from the fruit of T_1 (15:1), which was statistically identical to T3 (5:1). The minimum weight of pulp (31.1g) was produced by T_2 (10:1 ratio). The results revealed that pulp weight per fruit had direct influence on fruit weight.

Number of seed per fruit: Higher number of seeds per fruit (18.0) was obtained from T_3 (15:1 ratio) and lowest (16.78) from T_2 (10:1 ratio) but there was no significant difference among the treatments.

Seed weight per fruit: The maximum weight of seeds (3.30g) per fruit was obtained from T_1 (15:1 female and male ratio). The minimum weight of seeds (3.22g) was recorded in T_2 (10:1) but three treatments were statistically at par.

Yield: Yield of pointed gourd varied significantly due to different plant sex density and ranged from 24.4 - 33.0 t/ha (Fig. 1). Highest yield (33.0t/ha) was produced by 15:1 female male sex density. These results are in agreement with the findings of Dash, *et al*. (2000). He observed female male ratio of 15:1 was found to be the best.

He also found that increasing the female plant population beyond 15 around one male resulted in significant reduction in the yield per hectare in this crop. The highest yield obtained from T_1 (15:1 ratio) was statistically similar to T_2 (10:1 ratio). Whereas, the minimum yield (24.4t/ha) was obtained from T_3 (5:1 ratio). Kumar *et al*. (1995) also observed significant variation among the treatment in respect of yield of fruit. The result indicated that higher density of male flower lower the yield. It can be assumed that higher density of male plant might give higher yield. But it did not happen in the present study. This can be explained by the fact that the higher density of male plant reduced the number of female plant per hectare; hence, the yield was reduced. Again, pointed gourd is a highly cross pollinated crop (Seshadri, 1989), hence, it can be assumed that at least one male plant corresponding to 10 or 15 female plant is sufficient for successful pollination.

Effect of harvesting stage

Effect of harvesting stage on the yield and quality of pointed gourd are present in Table 2. All the characteristics were statistically significant except days to 1st flowering, number of node at 1st flowering and number of shoot per plant. The characteristics like days to 1st flowering, vine length, number of node, number of shoot per plant at 1st female flowering, number of fruit per plant single fruit weight, weight of fruit per plant, fruit length, fruit width, pulp weight per fruit, number of seed per fruit, weight of seed per fruit and yield were presented below:

Days to female 1st flowering: It was observed that days to 1st flowering varied among the treatment and ranged from 119.8 to 121.3 days. Harvesting at 8 days after female flower anthesis took minimum days to first flowering (119.8 days) and 12 days after female flower anthesis required the maximum days to first flowering (121.3 days).

Vine length at 1st female flowering: The vine length at 1st female flowering varied significantly among the treatment (Table 2) and ranged from 126-165.6 cm. The longest vine length (165.6 cm) was recorded in harvesting at 16 days after female flower anthesis (S_3), which was identical to S_2. The shortest vine length (126.1cm) was recorded at harvesting at 8 days after female flower anthesis (S_1). Kumar *et.al.*, (1995) also observed significant variation in vine length of pointed gourd.

Number of node at 1st female flowering: The maximum number of nodes per vine was recorded 11.89 at harvesting at 12 days after female flower anthesis (S_2) and the minimum (10.56) was observed in S_1 at harvesting at 8 days after female flower anthesis. Singh and Prasad (1989a) also reported the wide range of variability for number of nodes per vine.

Number of shoot per plant: Number of shoots per plant is a very important character and plays a vital role in yield particularly in crops, which bears fruits in the leaf axils. In case of pointed gourd, flower and fruits were borne in the leaf axils of shoot and higher was the number of branches per plant higher was the number of flowers and fruits. Harvesting at 8 days after female flower anthesis gave the higher number of shoots per plant (3.2) and harvesting at 16 days after female flower anthesis (S_3) produced the lowest number of shoots (2.8) per plant.

Number of fruit per plant: The number of fruits per plant varied significantly among the treatment. The plants harvesting 12 days after female flower anthesis (S_2) produced the maximum number of fruits (152.6). Minimum number of fruits per plant (149.7) was obtained from S_1 (at harvesting 8 days after female flower anthesis). Prasad and Singh (1990a) also observed significant variation among the treatment of pointed gourd in respect of number of fruits per plant. The variation in number of fruit per plant might be due to genetically diversity.

Single fruit weight: Single fruit weight varied significantly among the treatment and ranged from 24.2g to 39.9g (Table 1). The highest fruit weight 39.9g was obtained from S_3 (harvesting at 16 days after female flower anthesis) and lowest fruit weight (24.2 g) from S_1 (harvesting at 8 days after female flower anthesis). The variation of fruit weight could be due to the genetically, physiological, nutritional or environmental influence. Prasad and Singh (1990a) reported similar results in respect of fruit weight in pointed gourd.

Weight of fruit per plant: Weight of fruit per plant varied significantly among the treatment and ranged from 3.29 kg to 4.66 kg. The maximum weight of fruits per plant (4.66 kg) was found in S_2 (harvesting at 12 days after female flower anthesis), which was statistically similar to the S_3 (harvesting at 16 days after female flower anthesis). The lowest number of fruit per plant (3.29kg) was obtained from S_1 (harvesting at 8 days after female flower anthesis). These results are in agreement with the findings of Singh and Whitehead. (1999).

Length of fruit: Length of fruit varied significantly among the treatment and ranged from 6.81 cm to 9.70 cm. Longest fruit was recorded in S_3 (harvesting at 16 days after female flower anthesis) while the shortest fruit (6.81cm) was produced by S_1 (harvesting at 8 days after female flower anthesis). The results on length of fruit supported by the findings of Prasad and Singh (1990a).

Radius of fruit: The width of fruits of pointed gourd varied significantly due to different treatment and ranged from 2.84 to 3.46 cm. The maximum fruit width (3.46 cm) was obtained from S_3 (harvesting at 16 days after female flower anthesis) but statistically identical to S_2 (3.40 cm) and lowest fruit width (2.48 cm) was recorded in S_1 (harvesting at 8 days after female flower anthesis). Singh and Prasad

(1989) also reported significant difference for fruit width in pointed gourd.

Pulp weight per fruit: Pulp weight varied significantly among the treatment and ranged from 17.9g to 40.4g. The maximum weight to pulp (40.4g) was obtained from the fruit of S_3 (harvesting at 16 days after female flower anthesis), which was significantly differed from other treatments. The minimum weight of pulp (17.9g) was recorded from S_1 (harvesting at 8 days after female flower anthesis). The results revealed that pulp weight of fruit had direct influence on average fruit weight of pointed gourd.

Number of seed per fruit: Significant variation was observed among the treatments in number of seeds per fruit. The maximum number of seed (18.6) per fruit was obtained from S_3 (harvest at 16 days after female flower anthesis), which was statistically similar to S_2 (harvest at 12 days after female flower anthesis). The minimum number of seeds per fruit (15.3) was found in S_1 (harvest at 8 days after female flower anthesis).

Seed weight per fruit: Seed weight per fruit varied significantly among the treatments and ranged from 1.2g to 4.8g. The maximum weight of seeds was recorded in S_3 (4.8g) and the minimum (1.2g) per fruit was recorded in S_1.

Yield: Yield of pointed gourd varied significantly due to different harvesting stage (Fig. 2). Higher yield (31.0t/ha) was produced by S_2 (harvest at 12days after female flower anthesis), which was statistically similar to S_3 (harvest at 16 days after female flower anthesis). The lowest yield (21.9 t/ha) was obtained from S_1 (harvest at 8 days after female flower anthesis).

Interaction effect of plant sex density (Female: male) and harvesting stage on the growth and yield of pointed gourd

The interaction effects of different plant sex density and different harvesting stage on the yield and quality of pointed gourd are presented in table 3. Days to 1st flowering, vine length at 1st female flowering, number of fruits per plant, single fruit weight, weight of fruit per plant, fruit length, fruit width, pulp weight per fruit, number of seeds per fruit and yield were found significantly influenced by the combined effect of plant sex densities and harvesting stages of fruit. The highest number of fruits per plant (165.0) was recorded from S_2T_1 (15:1 plant sex density with harvesting at 12 days after female flower anthesis), which was at par to S_3T_1. The highest weight of fruits (5.15kg) were obtained from S_2T_1 combination (15.1 plant sex density with harvest at 12 days after female flower anthesis) which was statistically similar to S_3T_1 (15:1 female male ratio with harvest at 16 days after (10:1 ratio with harvest at 12 days after female flower anthesis, S_2T_2 (female flower anthesis) and S_3T_2 (10:1 with harvesting at 16 days after female flower anthesis). The highest pulp weight (42.5)

was obtained from S_3T_1 (harvesting at 16 days after female flower anthesis when coupled with 15:1 plant sex density). But number of seeds per fruit (20.67) and weight of seeds per fruit (5.08 g) was obtained higher from S_3T_3 combination (plant sex density 5:1 with harvesting at 16 days after female flower anthesis). Yield was significantly affected by sex density and harvesting stage. The highest yield (34.32 t/ha) was produced by S_2T_1 (15:1 plant sex density and harvesting at 12 days after female flower anthesis, which was statistically similar to S_3T_1 combination (15:1 sex density and harvesting at 12 days after female flower anthesis).

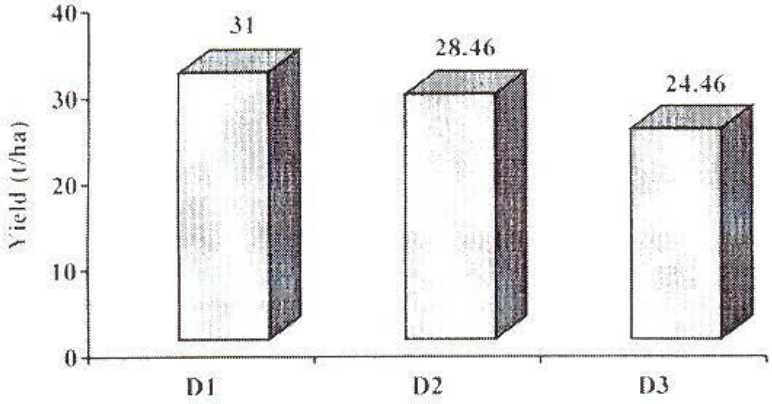

Fig. 1. Effect of plant sex densities on yield of pointed gourd

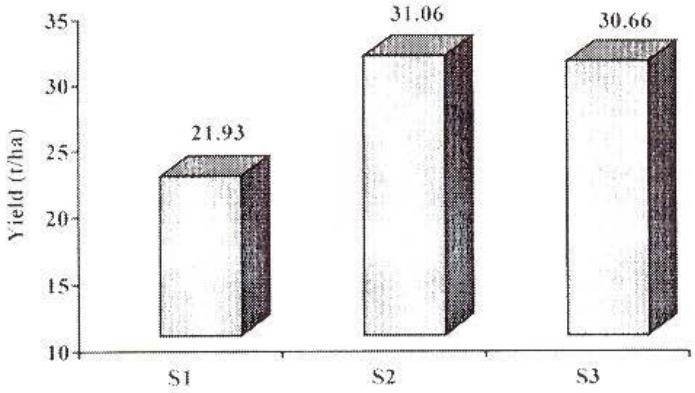

Fig. 2. Effect of harvesting stage on yield of pointed gourd

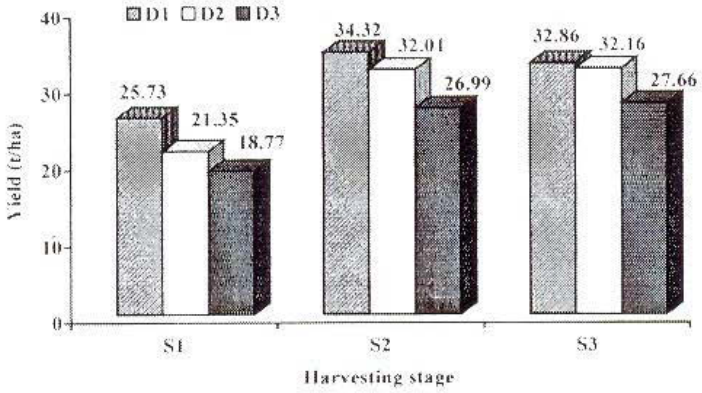

Fig. 3. Combined effect of harvesting stage and plant sex densities on yield of pointed

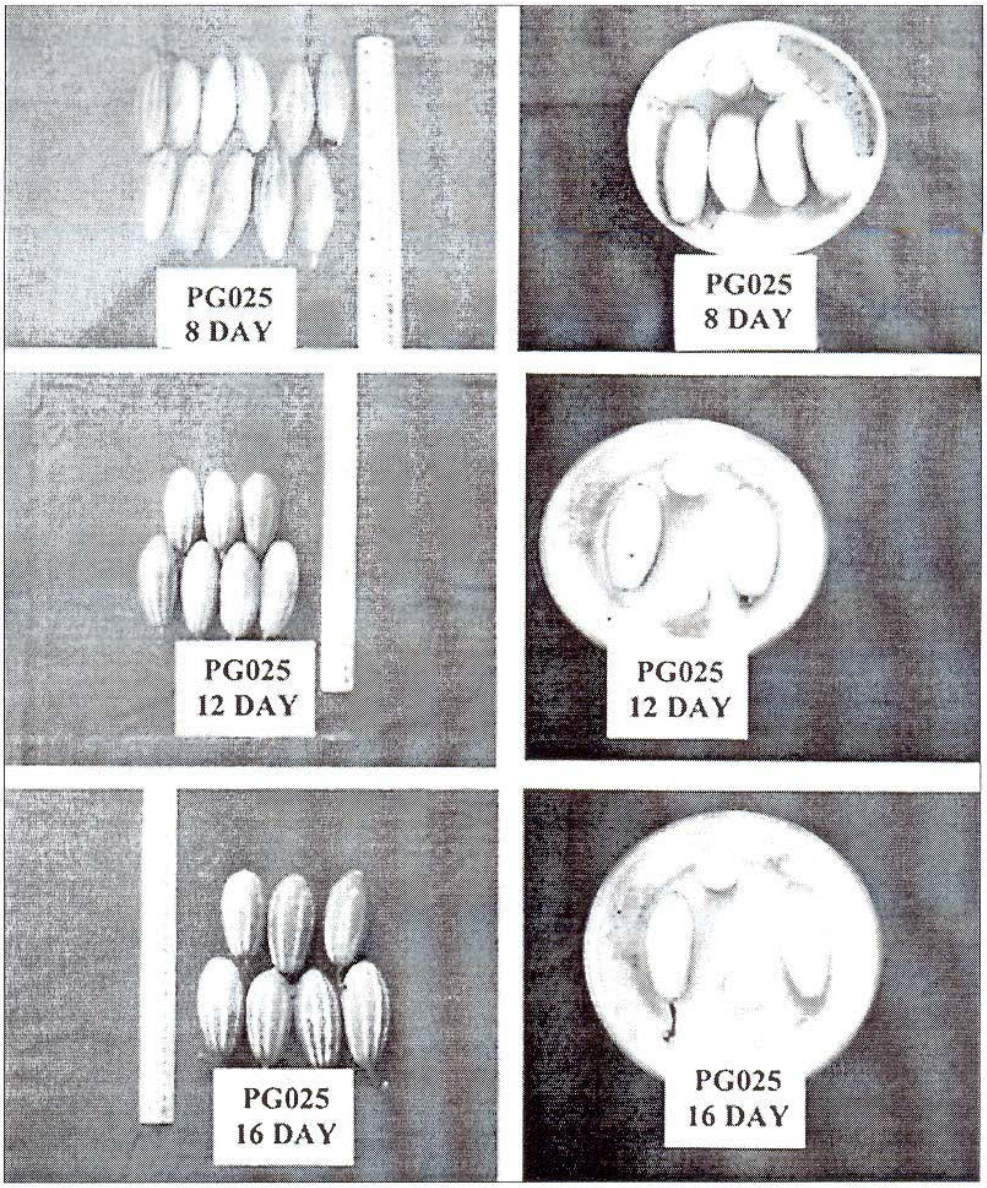

Fig. 4. 8 days and 16 days of harvesting stage respectively at female flower anthesis

Fig. 8 days and 16 days of harvesting stage respectively at female flower anthesis

Table 3. Interaction effects of sex plant density (female male ratio) and harvesting stage on the yield and quality of pointed gourd

Treatment	Days to 1st flowering	Vine length at 1st female flowering (cm)	No. of node at 1st female flowering	No. of shoot /plant	No. of fruit/ plant	Single fruit wt. (g)	Weight of fruit /plant (kg)	Fruit length (cm)	Fruit radius (cm)	Pulp wt (g)	No. of seed /fruit	Weight of seed/ fruit (g)
S_1T_1	121.3b	125.0c	11.0	3.0	159.0b	26.5e	3.86b	7.45de	2.98d	18.2d	15.6b	1.30
S_1T_2	109.3c	136.7bc	11.0	3.3	149.0c	25.17e	3.20c	6.68gh	2.80e	17.6d	14.3b	1.30
S_1T_3	128.7a	116.7c	9.6	3.3	141.0e	21.0f	2.81c	6.32h	2.74e	17.8d	16.0ab	1.20
S_2T_1	125.3a	110.7c	44.6	3.3	165.0a	40.17b	5.15a	7.80d	3.63a	38.0bc	16.33ab	3.86
S_2T_2	109.7c	163.3a	12.3	3.0	149.3c	34.83c	4.80a	7.2ef	3.34bc	37.5c	118.3ab	3.63
S_2T_3	129.0a	153.3ab	11.66	3.3	143.3d	31.33d	4.05b	6.79fg	3.22c	37.5c	16.3ab	3.60
S_3T_1	125.0a	175.0a	10.0	3.0	162.3ab	45.33a	4.93a	10.55a	3.70a	42.5a	18.67ab	4.86
S_3T_2	110.3c	153.3ab	10.66	2.6	146.7cd	39.50b	4.81a	9.62b	3.43a	38.3bc	19.6a	4.73
S_3T_3	127.7a	168.3a	11.33	3.0	143.0de	35.0c	4.15b	8.95a	3.35c	40.35ab	20.67a	5.08
CV%	1.76	9.74	9.77	20.53	1.83	5.55	5.61	3.29	2.80	4.65	12.03	7.78

In column, similar letter(s) do not differ significantly at 5% level of significance.

Where,

T_1 = Female male ratio 15:1

T_2 = Female male ratio 10:1

T_3 = Female male ratio 5:1

S_1 = Harvesting at 8 days after female flower anthesis

S_2 = Harvesting at 12 days after female flower anthesis

S_3 = Harvesting at 16 days after female flower anthesis

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EFFECT OF GREEN MANURING CROPS IN DIFFERENT RICE BASED CROPPING PATTERNS ON SOIL FERTILITY UNDER IRRIGATED ECOSYSTEM

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ABSTRACT

Experiments were conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during July 1996 to December 1999. The objective was to find out the effect of green manuring crops in different rice based cropping patterns and their incorporation on soil fertility under irrigated ecosystem. Farmers' predominant cropping pattern, Boro -Fallow-T.aman (I_1) and five other pre-designed patterns were; Boro + *Azolla*-Fallow-T.aman + *Azolla* (I_2), Boro-*Sesbania rostrata*-T.aman (I_3), Boro-Mungbean-T.aman (I_4), Boro-Fallow-T.aman/Blackgram (I_5), and Boro-Fallow-T.aman/ Grass pea (I_6) were tested under irrigated ecosystem. The experiment was laid out in randomized complete block design with three replications. Results revealed that inclusion of green manuring crops in different cropping patterns and their incorporation into soil showed positive impact on soil fertility. After three years of study, soil fertility levels i.e., N, P, K, S and organic matter were found higher due to *in situ* incorporation of green of biomass. It was also observed that addition of biomass through *Azolla* grown with rice in both *boro* and T.*aman* seasons gradually enriched the organic matter content of the soil.

Key words: Green manuring, rice base cropping patterns, soil fertility, and irrigated ecosystem

INTRODUCTION

Rapid decline of Soil fertility is a problem of crop production in Bangladesh. The organic matter in croplands has been decreasing (Miah, 1994). Imbalance use of fertilizers, unplanned cultivation and improper management of soil have already caused not only stagnation but also decline in productivity of modern varieties.

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Intensive and continuous rice-based crop culture, replacement of local rice varieties by modern ones, decreasing jute cultivation, increasing adoption of power tillers for tillage operations and increasing use of dung and organic waste as fuel have been negatively affecting the status of soil organic matter. Increased cropping intensity and sustained productivity of the soil are the important options to achieve self-sufficiency in food. Sharp declining in soil fertility is a threat for sustainable crop production.

Farmers of Bangladesh are generally growing rice in three seasons viz. *aus*, *aman* and *boro*. They grow boro rice under irrigated ecosystem. Because of choice and cultural practice, farmers' do not sacrifice rice from their cropping patterns. The major irrigated pattern is Boro-Fallow-T.aman. Inclusion of green manuring crops and their biomass incorporation in the existing farmers' cropping practice may be the effective means to maintain soil fertility as well as crop productivity. Evidences have shown that the status of soil fertility can be improved through inclusion of green manuring crops and their biomass incorporation in the rice-rice cropping patterns (Choudhury *et al*., 2004; Rahman *et al*., 2005; BRRI, 2006). The study was undertaken to find out the effect of green manuring crops in different rice based cropping patterns on soil fertility under irrigated ecosystem

MATERIALS AND METHODS

Experiments were conducted at the Agronomy Field Laboratory of the Bangladesh Agricultural University, Mymensingh during July 1996 to December 1999. The soil of the experimental field lies in agro-ecological region of Old Brahmaputra Flood plain (AEZ #9). It belongs to the Sonatola series of non-calcareous dark grey floodplain type. The experiment consisted of six cropping patterns (One farmers' existing patterns and five pre-designed patterns under irrigated system). The existing pattern was Boro -Fallow-T.aman pattern (I_1) and the pre-designed patterns were Boro + *Azolla*-Fallow-T.aman + *Azolla* (I_2), Boro - *Sesbania rostrata*-T.aman (I_3), Boro -Mungbean-T.aman (I_4), Boro -Fallow-T.aman + Blackgram (I_5), and Boro e-Fallow-T.aman /Grass pea (I_6). Seven consecutive rice-cropping seasons were covered to complete the experiment. The first rice crop was grown during transplant T.aman season of 1996 and the last rice crop also T. aman of 1999. The land was prepared well by using power tiller and country plough during first cropping. After then country plough, spade and ladder were used in the permanent plots for a good tilth before growing each crop. The experiment was laid out in a randomized complete block design with three replications. The test varieties were BR14, BRRI dhan29 and BRRI dhan 29 during boro seasons of 1997, 1998 and 1999, respectively. Varieties used in T.aman seasons of 1996, 1997, 1998 and 1999 were BR23, BR22, BR11 and BRRI dhan32, respectively. Fertilizers NPKS were applied @ 80-22-33-10 kg ha^{-1} during boro seasons and @ 70-22-33-10 kg ha^{-1} during T.aman seasons, respectively. All fertilizers were applied as basal dose during final

land preparation of each rice crop except Urea, which was applied in three equal splits as top dress. Green manuring crops were grown and incorporated as per treatments. Dry matter incorporation through green biomass of green manuring crops has been mentioned by the authors in earlier publication (Kashem *et al*., 2005). Initial soil was collected and analysed for pH, N, P, K, S and OM. Soils were also collected and analysed for same elements after harvest of each rice crop. The data obtained from the experiments on different parameters were interpreted statistically and the significance of mean differences was adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Ef1fect on Soil pH

Soil pH varied significantly in post-harvest soil due to green manuring crops under different cropping patterns of irrigated ecosystem (Table 1). Results revealed that the variation of pH did not follow any particular pattern in different seasons. But in general pH were found lower in post-harvest soil of T.*aman* seasons than those of boro seasons. It might be due to rainfall during the collection of soil after *boro* seasons and dry soil collected after T. *aman* season. It was reported earlier that the pH of most soils tended to change towards neutrality after submergence and attain an equilibrium pH in the range of 6.50-7.50 (Yamane, 1978 and Ponnamperuma, 1978). The lower pH resulted after 6th crops where green manuring crops were grown and biomass incorporated. This might be due to release of weak organic acid into the soil.

Table 1. Effect of green manuring crops on post harvest soil pH in different cropping patterns under irrigated ecosystem

Cropping pattern	Cropping season						
	T.*aman*96	*Boro*97	T.*aman*97	*Boro*98	T.*aman*98	*Boro*99	T.*aman*99
I_1	6.54f	6.92d	6.94a	6.66c	6.64c	6.96a	6.71a
I_2	6.95a	6.87e	6.89a	6.95ab	6.52d	6.98a	5.91d
I_3	6.69d	6.96b	6.76b	6.83bc	6.86b	6.81b	5.63c
I_4	6.57e	6.94c	6.66cd	6.84bc	6.64c	6.64c	6.16c
I_5	6.84b	6.62f	6.65d	7.08a	6.95a	7.02a	6.37b
I_6	6.74c	6.97a	6.74bc	6.75c	6.81b	6.84b	6.42b
CV (%)	0.32	1.24	0.46	1.06	1.32	0.36	0.90

Initial pH value = 6.80, Figures in a column having a common letter(s) do not differ significantly whereas dissimilar latter(s) differ significantly by DMRT test.

I_1: Boro-Fallow-T.aman ; I_2: Boro + Azolla-Fallow-T.amane + Azolla; I_3: Boroe-Sesbania rostrata-T.aman; I_4: Boro rice-Mungbean-T.aman ; I_5: Boro rice-Fallow-T.aman (relayed Blackgram); I_6: Boro-Fallow-T.aman (relayed Grass pea)

Effect on total Nitrogen (N)

Total N in soil varied significantly under different green manuring treatments except T.*aman* season of 1996 (Table 2). It was observed that total N was always high in I_2 where *Azolla* was grown both in *boro* and T.*aman* and its biomass incorporated with the soil. Results indicated that total N in post harvest soils gradually increased due to green manuring in each year under different treatments. After three years of study, total N in the post harvest soil of T.*aman* season in 1999 indicated that the significant increase was due to treatments under green manuring (I_2, I_3, I_4 and I_6). Sharma *et al.* (2000) reported that the *Sesbania* green manuring and mungbean residue incorporation practices interacted positively with inorganic fertilizers in building up soil total N. Chaphale *et al.* (2000) observed that the addition of *Gliricidia* over a period of 5 years led to increase in total N of post harvest soil.

Table 2. Effect of green manuring crops on post harvest soil total N (%) in different cropping patterns under irrigated ecosystem

Cropping pattern	Cropping season						
	T.*aman*96	*Boro*97	T.*aman*97	*Boro*98	T.*aman*98	*Boro*99	T.*aman*99
I_1	0.081	0.082e	0.085f	0.084d	0.081d	0.085c	0.083c
I_2	0.081	0.094a	0.110a	0.114a	0.116a	0.117a	0.118a
I_3	0.081	0.087c	0.089e	0.093c	0.105bc	0.105b	0.112ab
I_4	0.081	0.088b	0.097b	0.098b	0.107b	0.103b	0.115ab
I_5	0.082	0.086d	0.092d	0.095c	0.097c	0.103b	0.109b
I_6	0.082	0.087c	0.094c	0.095c	0.098c	0.102b	0.111ab
CV (%)	1.51	1.87	2.73	1.39	0.51	1.28	1.69

Initial total N = 0.081%.

Figures in a column having a common letter(s) do not differ significantly whereas dissimilar latter(s) differ significantly by DMRT test.

ns - Not significant

I_1: Boro-Fallow-T.aman; I_2: Boro + Azolla-Fallow-T.aman + Azolla; I_3: Boroe-Sesbania rostrata-T.aman; I_4: Boro rice-Mungbean-T.aman; I_5: Boro rice-Fallow-T.aman (relayed Blackgram); I_6: Boro-Fallow-T.aman (relayed Grass pea)

Effect on Available Phosphorus (P)

Available P in post harvest soil of seven consecutive rice seasons was significantly affected by green manuring in different rice based cropping patterns under irrigated ecosystem (Table 3). Soils analyzed after T.*aman* season of 1996 indicated that available P increased due to green manuring. The highest available P obtained in I_6 when grass pea was relayed with T.*aman* rice and was identically followed by I_5 in 1996 but showed highest P in treatment I_2 after 6 rice crops. The available P in soils was always high in each season from *boro* season 1997 towards T.*aman* season 1999 (Table 3). Results are in conformity with those of Raju and Reddy (2000) and Mehalatha *et al*. (2000). They observed that green manuring significantly improved the fertility status of soil and it was pronounced by the *Dhaincha* incorporation by increasing available P at post harvest soil. Results revealed that addition of green biomass including *Azolla* grown with rice in each season gradually enriched the available P over other treatments. It might be due to P loving intake behaviour of *Azolla* and then to fix in the soil (Mian and Kashem, 1995).

Table 3. Effect of green manuring crops on post harvest soil available P (ppm) in different cropping patterns under irrigated ecosystem

Cropping pattern	Cropping season						
	T.*aman*96	*Boro*97	T.*aman*97	*Boro*98	T.*aman*98	*Boro*99	T.*aman*99
I_1	9.95c	10.40e	10.91f	10.99f	10.24f	10.43f	10.95f
I_2	10.10b	12.60a	14.77a	15.95a	16.93a	16.95a	17.18a
I_3	9.79d	10.40e	12.45c	15.82b	16.24b	16.1b	16.35b
I_4	9.91cd	10.6d	12.68b	14.89c	15.12c	15.21c	16.15c
I_5	10.8a	10.85c	11.71e	12.46d	12.76e	13.14e	14.11e
I_6	10.81a	11.21b	12.14d	12.36e	13.77d	13.84d	14.25d
CV (%)	0.51	0.52	0.43	1.22	1.14	3.05	0.24

Initial soil available P = 10.00 ppm

Figures in a column having a common letter(s) do not differ significantly whereas dissimilar latter(s) differ significantly by DMRT test., ns-not significant

I_1: Boro-Fallow-T.aman; I_2: Boro + Azolla-Fallow-T.aman + Azolla; I_3: Boroe-Sesbania rostrata-T.aman; I_4: Boro rice-Mungbean-T.aman ; I_5: Boro rice-Fallow-T.aman (relayed Blackgram); I_6: Boro-Fallow-T.aman (relayed Grasspea)

Effect on Exchangeable Potassium (K)

Variations in exchangeable K in post harvest soil were significant due to green manuring in different cropping patterns under irrigated ecosystem except T.*aman* season of 1996 (Table 4). The concentration of exchangeable K in post harvest soil was higher in I_2 where *Azolla* was grown with rice in both *boro* and T.*aman* seasons followed by incorporation of its biomass into soil. This was identically followed by I_3 where *Sesbania rostrata* was grown as green manure and incorporated into soil for T.*aman* season followed by grasspea relayed with T.*aman* rice (I_6) and incorporated into soil before *boro* seasons. The exchangeable K in soil gradually increased over time due to combined use of green manure and chemical fertilizer. Integrated use of organic and inorganic fertilizers also reported to enhance exchangeable K in soils (Rahman, 1999 and Islam, 2000).

Table 4. Effect of green manuring crops on post harvest soil exchangeable K (meq/100 g soil) in different cropping patterns under irrigated ecosystem

Cropping pattern	Cropping season						
	T.*aman*96	*Boro*97	T.*aman*97	*Boro*98	T.*aman*98	*Boro*99	T.*aman*99
I_1	0.23	0.22d	0.22c	0.22c	0.22d	0.23b	0.23d
I_2	0.23	0.25a	0.25a	0.26a	0.26a	0.27a	0.28a
I_3	0.22	0.23c	0.25a	0.23bc	0.25a	0.24b	0.27a
I_4	0.23	0.23c	0.24b	0.23bc	0.24b	0.24b	0.25b
I_5	0.23	0.24b	0.24b	0.24b	0.23c	0.25ab	0.24c
I_6	0.23	0.25a	0.24b	0.25a	0.23c	0.26a	0.25b
CV (%)	2.40	3.01	1.76	4.63	1.72	3.05	0.82

Initial soil exchangeable K = 0.22 meq/100 g soil.

Figures in a column having a common letter(s) do not differ significantly whereas dissimilar latter(s) differ significantly by DMRT test.

ns - not significant

I_1: Boro -Fallow-T.aman; I_2: Boro + Azolla-Fallow-T.aman + Azolla; I_3: Boro-Sesbania rostrata-T.aman; I_4: Boro-Mungbean-T.aman; I_5: Boro-Fallow-T.aman (relayed Blackgram); I_6: Boro -Fallow-T.aman (relayed Grasspea)

Effect of Available Sulphur (S)

Available S in post harvest soil was remarkably influenced by green manuring in different cropping patterns under irrigated ecosystem (Table 5). Culture of *Azolla* with rice in both seasons and its incorporation into soil as green manure (I_2) showed the highest available S in post harvest soils of each season. In this treatment, it was observed that the available S gradually increased over time due to *Azolla* biomass incorporation in every rice season. In general, available S in post harvest soil increased due to green manuring under different treatments while slight increase of available S was observed in fertilizer alone treatment. Sharma *et al*. (2001) reported that the integrated use of inorganic fertilizers along with green manuring increased significantly the available S at post harvest soil over their initial status of soil.

Table 5. Effect of green manuring crops on post harvest soil available S (ppm) in different cropping patterns under irrigated ecosystem

Cropping pattern	Cropping season						
	T.*aman*96	*Boro*97	T.*aman*97	*Boro*98	T.*aman*98	*Boro*99	T.*aman*99
I_1	10.42	11.20c	11.42c	11.55d	11.21e	12.11f	11.14d
I_2	10.41	13.00a	14.00a	15.16a	15.24a	17.10a	16.54a
I_3	10.39	11.00c	12.11b	12.00c	13.16c	13.15e	14.22b
I_4	10.38	11.10c	12.15b	12.14c	13.27b	13.28d	14.16bc
I_5	10.45	12.00b	12.10b	13.21b	13.12d	14.14c	14.12c
I_6	10.55	12.00b	12.12b	13.22b	13.13cd	14.23b	14.22b
CV (%)	1.10	0.64	0.24	0.53	1.12	0.22	1.21

Initial soil available S = 10.00 ppm.

Figures in a column having a common letter(s) do not differ significantly whereas dissimilar letter(s) differ significantly by DMRT test.

ns - not significant

I_1: Boro-Fallow-T.aman ; I_2: Boro + Azolla-Fallow-T.aman + Azolla; I_3: Bore-Sesbania rostrata-T.aman; I_4: Boro-Mungbean-T.aman ; I_5: Boro-Fallow-T.aman (relayed Blackgram); I_6: Boro-Fallow-T.aman (relayed Grasspea)

Effect of Organic matter (OM)

Organic matter status of post harvest soil was significantly influenced by growing green manuring crops in different cropping patterns under irrigated ecosystem and their biomass incorporation into the soil (Table 6). Organic matter varied significantly in the post harvest soil of T.*aman* in 1996 where the highest soil test value of OM (1.34 per cent) was recorded due to grasspea relayed with T.*aman* rice. In *boro* season of 1997 and 1998, the highest soil organic matter content (1.48 &

1.55 per cent) was observed in I_2 where *Azolla* was grown with rice in both the seasons and incorporated into soil as green manure in both T.*aman* and *boro*. Similar trend was observed in 1997 T.*aman* season

Table 6. Effect of green manuring crops on post harvest soil organic matter content (%) in different cropping patterns under irrigated ecosystem

Cropping pattern	Cropping season						
	T.*aman*96	*Boro*97	T.*aman*97	*Boro*98	T.*aman*98	*Boro*99	T.*aman*99
I_1	1.31c	1.31d	1.30f	1.30f	1.29f	1.29d	1.28e
I_2	1.31c	1.48a	1.53a	1.55a	1.58a	1.64a	1.68a
I_3	1.31d	1.31d	1.45b	1.42d	1.51b	1.45c	1.58b
I_4	1.31c	1.31d	1.43c	1.41e	1.49c	1.46c	1.51c
I_5	1.33b	1.45c	1.41e	1.47c	1.46e	1.52b	1.48d
I_6	1.34a	1.46b	1.42d	1.50b	1.47d	1.53b	1.49d
CV (%)	0.46	0.75	0.43	1.84	1.65	1.09	0.88

Initial soil organic matter = 1.31%.

Figures in a column having a common letter(s) do not differ significantly whereas dissimilar latter(s) differ significantly by DMRT test.

I_1: Boroe-Fallow-T.aman ; I_2: Boro + Azolla-Fallow-T.aman + Azolla; I_3: Boroe-Sesbania rostrata-T.aman ; I_4: Boro-Mungbean-T.aman ; I_5: Boro-Fallow-T.aman (relayed Blackgram); I_6: Boro-Fallow-T.aman (relayed Grasspea)

In boro season of 1999, the highest OM content (1.64 per cent) was obtained in I_2 when *Azolla* was grown with rice in both seasons and incorporated into soil. Treatments I_3 and I_4 showed slightly decrease in OM than previous season. Again, in T. *aman* season, OM was also found highest in I_2 treatment. In all growing seasons fertilizer alone treatment (I_1) showed the lowest OM values. Results revealed that addition of green biomass through *Azolla* grown with rice in each season gradually enriched the organic matter content of the soil. Three years experiments showed that fertilizer use alone depleted soil organic matter to some extent over initial state while I_2 treatment with Azolla showed the highest enrichment of organic matter compared to other treatments. This was due to higher biomass and dry matter production through Azolla grown crops in Boro and T. aman seasons (Kashem *et al*. 2005). Mehalatha *et al*. (2000) reported that the use of green manuring crops significantly improved the soil fertility by increasing OC content, available soil N, P and S at post harvest stage. Results are also in conformity with those of Sharma *et al*. (2001), and Karim (1998).

Effect of soil properties on yields

Responses to grain yields of rice due to incorporation of green manuring crops in different rice cropping patterns under irrigated ecosystem were significantly positive. All the green manuring treatments showed higher grain yield compared to farmers' rice-fallow-rice pattern (Table 7). It was also found that the I_2 treatment performed best in respect of rice grain yield. These higher grain yields (straw yields were also higher) were supported by the higher soil fertility obtained due to green manuring under different cropping patterns. Higher straw yields provided support in favour of higher soil fertility obtained due to green manuring (Table 8).

Overall results revealed that inclusion of green manuring crops in different cropping patterns and their incorporation into the soil showed positive impact on soil fertility. It was also observed that addition of *Azolla* gradually enriched the organic matter content of the soil. Though incorporation of one green manure crop slightly decreased the soil nutrients, but further incorporation enhanced nutrients in post harvest soil of succeeding rice. Farmer can use any one of the options tried in the experiment as per their soil condition and resource availability. Moreover, *Azolla* as intercrop and *Sesbania rostrata* as relay crop can give more benefit than others options.

Table 7. Effect of green manuring crops on grain yield of rice in different cropping patterns under irrigated ecosystem

Cropping pattern	Cropping season						
	T.*aman*96	*Boro*97	T.*aman*97	*Boro*98	T.*aman*98	*Boro*99	T.*aman*99
I_1	3.68	3.70b	3.68b	5.44b	4.70c	5.51b	5.58b
I_2	3.56	4.46a	4.23a	6.44a	5.40ab	6.60a	6.35a
I_3	3.61	3.68b	4.32a	6.07ab	5.60a	6.38a	6.43a
I_4	3.73	3.74b	4.19a	6.25a	5.40ab	6.13ab	6.20ab
I_5	3.64	4.20a	3.90ab	6.45a	5.02bc	6.50a	5.97ab
I_6	3.72	4.22a	3.98ab	6.70a	5.13b	6.41a	6.13ab
CV (%)	3.47	3.01	3.84	4.05	3.06	4.21	3.85

Figures in a column having a common letter(s) do not differ significantly whereas dissimilar letter(s) differ significantly by DMRT test., ns=not significant

I_1: Boroe-Fallow-T.aman ; I_2: Boro + Azolla-Fallow-T.aman + Azolla; I_3: Boroe-Sesbania rostrata-T.aman ; I_4: Boro-Mungbean-T.aman ; I_5: Boro-Fallow-T.aman (relayed Blackgram); I_6: Boro-Fallow-T.aman (relayed Grasspea)

Table 8. Effect of green manuring crops on straw yield of rice in different cropping patterns under irrigated ecosystem

Cropping pattern	Cropping season						
	T.*aman*96	*Boro*97	T.*aman*97	*Boro*98	T.*aman*98	*Boro*99	T.*aman*99
I_1	4.43	4.77c	4.17c	6.00c	5.17	5.69b	5.95
I_2	4.65	5.73ab	5.01ab	6.50ab	6.17	6.63a	6.76
I_3	4.68	4.98bc	5.37a	6.37ab	6.15	6.65a	6.83
I_4	4.75	4.90c	5.08ab	6.30bc	6.32	6.50a	6.63
I_5	4.71	5.71ab	4.94ab	6.48ab	5.80	6.73a	6.58
I_6	4.57	5.83a	4.82b	6.67a	5.85	6.47a	6.62
CV(%)	4.65	5.43	3.86	2.89	8.17	3.66	5.40

Figures in a column having a common letter(s) do not differ significantly whereas dissimilar letter(s) differ significantly by DMRT test., ns=not significant

I_1: Boro-Fallow-T.aman; I_2: Boro + Azolla-Fallow-T.aman + Azolla; I_3: Boro-Sesbania rostrata-T.aman; I_4: Boro-Mungbean-T.aman; I_5: Boro-Fallow-T.aman (relayed Blackgram); I_6: Boro -Fallow-T.aman (relayed Grasspea)

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PHOTOSYNTHETIC CHARACTERS, SPAD VALUE AND NITROGEN USE EFFICIENCY OF TRADITIONAL *AUS* RICE (*Oryza sativa L.*) CULTIVARS

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ABSTRACT

Field experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, Bangladesh during *Aus* season, 2003. Three nutrient levels and five traditional *Aus* rice cultivars formed the treatments in the split plot design. Traditional *Aus* rice cultivars recorded significantly highest photosynthetic rate (Pn) in case of high nutrient level (HNL). Pn ranged from 15.11 to 24.14 $\mu molm^{-2} S^{-1}$ irrespective of cultivar. Gambir 2 ranked the top (23.08 $\mu molm^{-2} S^{-1}$) and Goasail was the lowest (17.77 $\mu molm^{-2} S^{-1}$) for Pn. The SPAD values ranged from 40.27 to 42.35 irrespective of cultivars. Goasail and Gambir 2 were considered efficient to utilize the low level of nitrogen by demonstrating higher SPAD value. Straw nitrogen (%), nitrogen uptake (straw, grain and total) and physiological nitrogen use efficiency (PNUE) showed significant differences due to variable nutrient levels at maturity while grain nitrogen % did not show significant difference. Gambir 2, Tarabali and Balam showed significantly higher PNUE. Goasail ranked the top in respect of grain nitrogen content.

Key words: *Oryza sativa* L., photosynthetic rate, SPAD, physiological nitrogen use efficiency

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INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food in Bangladesh. It provides about 75% calorie and 55% protein in the average daily diet of the people (Bhuiyan *et al.,* 2002). The demand of rice will increase and be met from our limited and shrinking land resources. The adoption of modern rice varieties has even though increased rapidly but the total rice area did not change much since 1971. Still a substantial area is cultivated with local traditional rice varieties because of land type and hydrological conditions. The extension of high yielding varieties (HYVs) in those areas seems difficult. The increasing yield of traditional local cultivars may have some significant importance for future food security. Therefore, the traditional varieties having efficient genotypes and good nutrients uptake behavior and utilization capacity should be selected. The yield potential of modern varieties remained static since the release of IR8 in 1966 (Lampe, 1994; Khush, 2000). To maximize yield under low-nutrient conditions, increase nutrient uptake and utilization efficiency may be considered as the best way.

Photosynthetic capacity is considered the most important physiological character, which enhances the yield of rice (Palit *et al.,* 1979). Momin (2003) evaluated genotypes to identify the potential rice genotypes in relation to photosynthesis and specific potential traits of flag leaf that played vital role in the photosynthesis and economic yield. Hamid *et al.,* (2004) reported that cultivars showed a great deal of variation in photosynthetic rates during growth stages. Arjunan *et al.,* (1990) reported that photosynthetic rate (Pn), dry matter production (DMP), grain yields and harvest index varied significantly among cultivars. Pn decreased progressively towards the reproductive phase. A positive correlation was found between Pn at 95 days after sowing (DAS) and grain yield. DMP was positively correlated with Pn at 65 DAS.

Acquisition of applied nitrogen by rice crop is typically less than 40% in farmer's fields (Craswell and Vlek, 1979, Cassman *et al.,* 1993). Some techniques like deep placement of urea, split nitrogen application, pre-planting incorporation of coated and controlled release urea, the leaf chlorophyll meter and leaf color chart for nitrogen management strategies could reduce nitrogen losses and improve fertilizer use efficiency (Katyal *et al.,* 1985, Kumar *et al.,* 1989; Peng, *et al.,* 1996; Balasubramanian *et al.,* 1999). Beside, one of the important ways to increase nitrogen efficiency is to create or identify cultivars with high nitrogen efficiency. Genotypic variation in nutrient uptake and utilization by plants indicate that selection for such character could be an effective avenue for crop improvement (Yau and Thurling, 1987). Therefore, this study was undertaken to evaluate the photosynthetic activity,

SPAD value, and nitrogen uptake and utilization efficiency of traditional Aus genotypes under limiting condition of nitrogen.

MATERIALS AND METHODS

Field experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur experimental farm during *Aus* season,2003. Three variable nutrient levels and five traditional *Aus* rice genotypes formed the treatments in a split plot design with three replications. The variable nutrient levels that formed the main plot treatment were i) Control (no nutrient added) ii) MNL (Moderate nutrient level=34N:5P:5K kg/ha); iii) HNL (High nutrient level= 46N:8P:12K kg/ha). Five diverse genotypes were Goasail - V_1 from Comilla district, Balam - V_2 from Sylhet district, Tarabali - V_3 from Sylhet district, Sada boro - V_4 from Faridpur district and Gimbir 2 - V_5 from Dinajpur district.

Seeds were soaked on 27 March 2003 and the sprouted seeds were sown in a well-managed seedbed. Necessary care of seedlings was taken in the seedbed. Recommended doses of P and K were incorporated in the selected treatment plots. Twenty-seven days old seedlings were transplanted in 5 x 3-m plot with a spacing of 25 x 15 cm on 22nd April, 2003. Nitrogen in the form of urea was top-dressed at 15, 35 and 55 DAT. The experimental plots were kept clean by hand weeding until flowering. Other intercultural operations were done as and when necessary. For the measurement of photosynthetic rate (Pn) a single plant was transferred to a pot at 10 days after transplanting (DAT). Based on the soil volume urea top dressings were done. Pots were placed in a well open flat ground. Each genotype had 3 pots.

At flowering SPAD (Soil plant analysis development) reading was taken from the flag leaves. Three measurements were taken from each hill and 3 hills were considered from each plot. A chlorophyll meter (SPAD-502, Milonta Camera Co. Japan) was used for recording the SPAD value. Photosynthetic rate (Pn) and associated parameters were measured using the flag leaves from the pots. Pot with plant was transferred under the illuminated uniform artificial light condition at Physiological Laboratory, BSMRAU. Portable Photosynthesis System (LiCOR-6200) was used to measure the Pn and associated parameters. Total nitrogen content was analyzed from whole plant sample by Kjeldhal method. Total nitrogen uptake and physiological nitrogen use efficiency were calculated using the following formulae (Mamin, 2003):

$$\text{Total nitrogen uptake (g/hill)} = \frac{\text{Total nitrogen\%} \times \text{above ground total dry matter}}{\text{Grain yield (at 14\% moisture)}}$$

$$\text{Physiological nitrogen use efficiency} = \frac{\text{(grain g/ N uptake)}}{\text{Total nitrogen uptake}}$$

ANOVA was performed and means were separated by DMRT using MSTATC. Beside, raw data were compiled and regression analyses and graphs were prepared using Microsoft Excel.

RESULTS AND DISCUSSIONS

Photosynthetic rate

Varying nutrient levels showed significant differences on photosynthetic rate (Pn) at flowering stage (Fig. 1). Pn rate ranged from 15.11 to 24.14 μmolm^{-2} S^{-1} irrespective of genotypes. HNL recorded significantly highest Pn rate followed by MNL and control respectively. Palit *et al.,* (1979) concluded that photosynthetic characteristics are the most important criterion in yield improvement of rice.

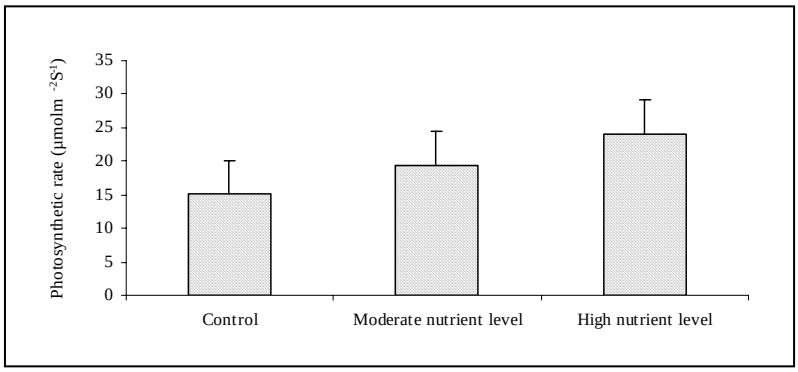

Fig. 1. *Effect of variable nutrient levels on the photosynthetic rates (Pn) of rice genotypes at flowering during T. Aus season, 2003.*

Genotypes used in the present study showed significant differences in photosynthetic activity at flowering under variable nutrient levels (Fig. 2). Marked variation in photosynthesis was observed among the rice cultivars by some workers (Hamid *et al.,* 2004; Sharma and Singh 1994; Tripthy *et al.,* 1989; Dey *et al.,* 1989;

Momin, 2003). The results showed that Gambir 2 (23.08 $\mu molm^{-2} S^{-1}$) ranked the top in Pn rate followed by Sada boro (20.51 $\mu molm^{-2} S^{-1}$) while Goasail (17.77 $\mu molm^{-2} S^{-1}$) was at the lowest. High photosynthetic rate was reflected in Gambir 2, Sadaboro and Trarbali, which was accounted for higher mesophyll conductance. High Pn in the varieties Gambir 2 and Sadaboro was also supported by high CO_2 gradient. Stomatal conductance was also higher in Gambir 2 and Sada boro. Ishii (1988) opined that breeding programme for high yielding varieties should be considered on the basis of Pn rate in flag leaf during the grain ripening stage. It was also noted that Gambir 2 had higher Pn rate along with high mesophyll conductance value.

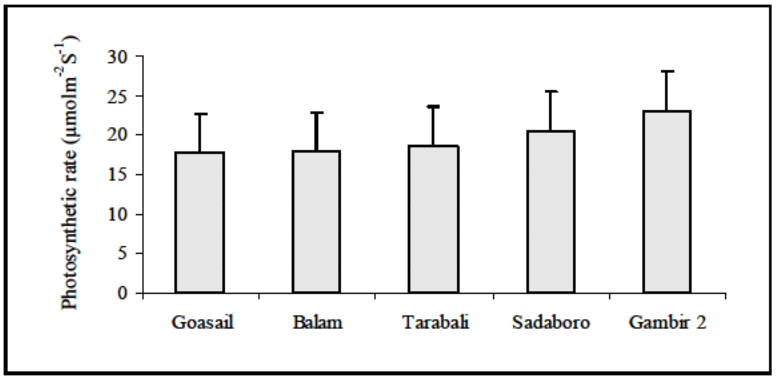

Fig. 2. *Performance of rice genotypes for photosynthetic rate (Pn) as influenced by variable nutrient levels at flowering during T. Aus season, 2003.*

Positive functional relationship (Fig. 4) of Pn and mesophyll conductance was considered the major determinant of variation of photosynthesis across the genotypes. A very strong positive relationshiop (R^2=0.9834) was observed between Pn and mesophyll conductance. Similar results were obtained by Mamin, 2003; Saitoh *et al.,* 1991 in their studies.

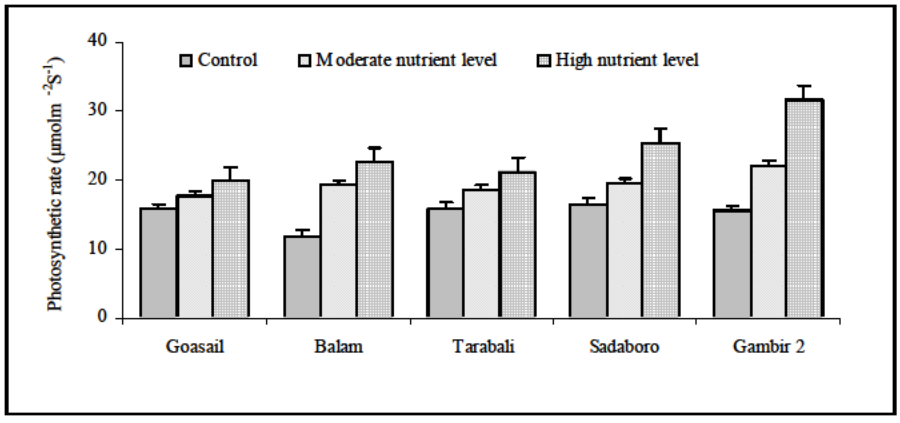

Fig. 3. *Varietal performance of rice genotypes for photosynthetic rate (Pn) as influenced by variable nutrient levels at flowering during T. Aus season, 2003.*

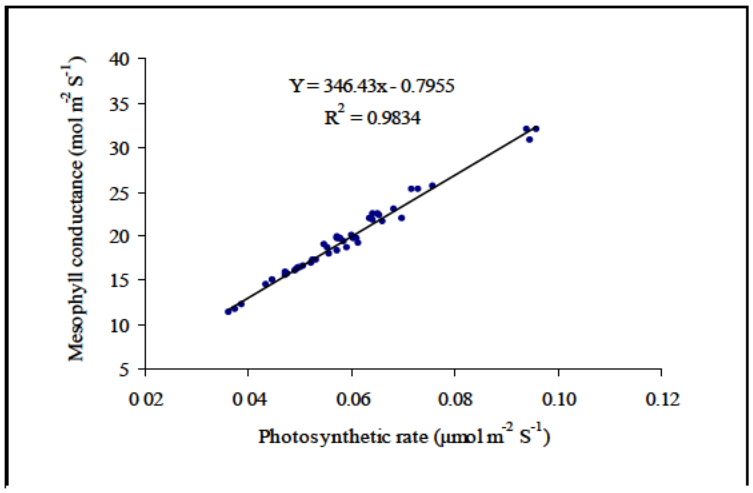

Fig. 4. *Functional relationship between photosynthetic rate (Pn) and mesophyll conductance of rice genotypes at flowering stage during T. Aus 2003.*

SPAD (Soil Plant Analysis Development) Value

SPAD reading accounted for variable nutrient levels and showed that added nutrient treatments showed considerably higher SPAD reading at flowering (Fig. 5). The SPAD values ranged from 40.27 to 42.35. The mean SPAD values among the genotypes revealed that Goasail accounted for the highest value (42.47) followed by Gambir 2 (41.49) and Sadaboro (40.57) irrespective of nutrient levels (Fig.6). It was well established that SPAD based nitrogen management needs considerably lower amount of nitrogen than the standard nitrogen management practices without any yield losses (Ali, 2005; Miah and Ahmed 2002). Several workers reported higher productivity (Panaullah *et al.,* 1999 and Islam *et al.,* 1998) and agronomic efficiency of chlorophyll based N doses compared to conventional method of N application in rice.

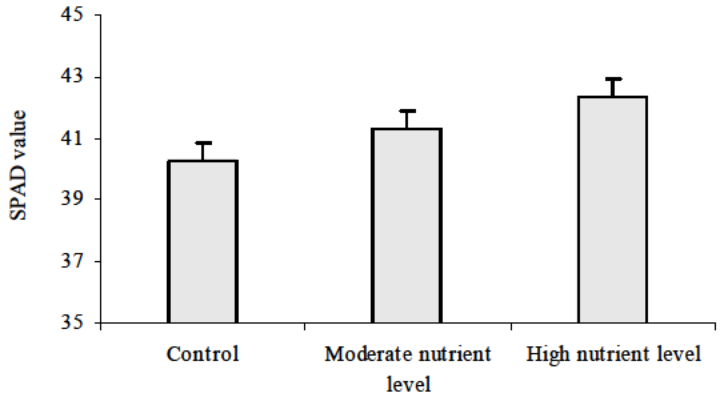

Fig. 5. Effect of variable nutrient levels on SPAD value of rice genotypes at flowering during T. Aus season, 2003

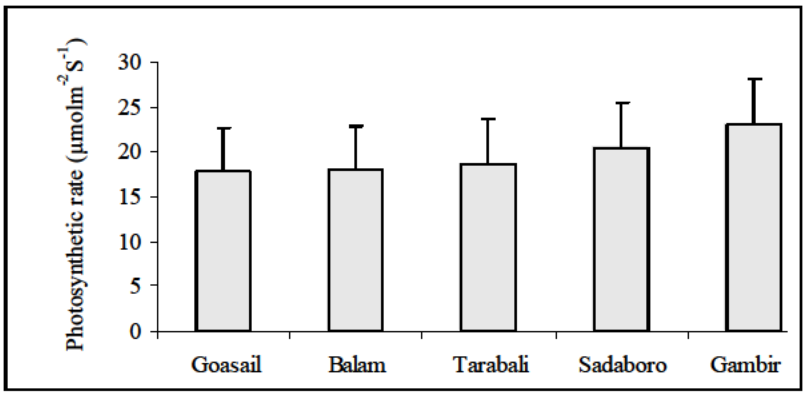

Fig. 6. Performance of rice genotypes for SPAD as influenced by variable nutrient levels at flowering during T. Aus season, 2003

The SPAD value of individual genotype under variable nutrient levels demonstrated that Balam, Tarabali and Sada boro had unique trend i.e. application of higher nutrient increased the SPAD value while Goasail and Gambir 2 accounted for highest SPAD value in moderate nutrient level (Fig. 7). Thus, Goasail and Gambir 2 might be considered efficient to utilize the low nitrogen level by demonstrating higher SPAD value. Importance of SPAD value was demonstrated by Peng *et al.*, (1996) which may be used directly to monitor leaf N status in rice and determine the time of top dressing of nitrogen.

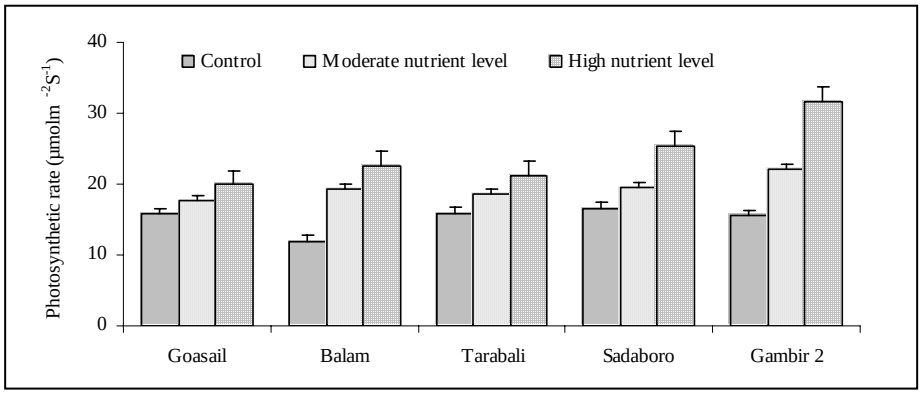

Fig. 7. *Varietal performance of rice genotypes for SPAD value as influenced by variable nutrient levels at flowering during T. Aus season, 2003*

Nitrogen Uptake and Physiological Nitrogen Efficiency

Nitrogen content (tissue N%), total nitrogen uptake and Physiological Nitrogen Use Efficiency (PNUE) were presented in Table 1. Straw nitrogen %, nitrogen uptake (straw, grain and total) and PNUE showed significant differences due to variable nutrient level at maturity while grain nitrogen % did not show any significant difference. It has been reported that rice varieties differ in efficiency in N-acquisition and physiological efficiencies (Choudhary *et al.,* 1998; Singh *et al.,* 1998). Treatment with added fertilizer (HNL and MNL) showed significantly higher nitrogen uptake as well as tissue nitrogen content. In the present study significantly higher PNUE in control treatment (no nutrient added) indicated the ability of utilization of native nitrogen by traditional genotypes. Roy *et al.* (2004) reported a great variation in N response; grain yield and N use efficiency among the rice varieties.

Table 1. Effect of variable nutrient levels on nitrogen content (%), nitrogen uptake and physiological nitrogen use efficiency (PNUE) of rice genotypes during T. *Aus*, season, 2003

Nutrient level	Nitrogen content (%)		Nitrogen uptake (Kg/ha)		Total uptake (Kg/ha)	PNUE (Kg grain Kg/N)
	Straw	Grain	Straw	Grain		
Control	0.74 b	1.32	43.07 b	24.75 b	67.82 b	28.27 a
MNL	1.05 a	1.60	66.42 a	32.59 a	99.01 a	20.90 b
HNL	0.92 ab	1.54	61.29 a	32.19 a	93.48 a	22.68 ab

Means followed by same common letter (s) are not differed significantly at 5 % level by DMRT

Control = No fertilizer added

MNL = Moderate nutrient level = 34N:5P:5K kg/ha

HNL = Higher nutrient level = 46N:8P:12K kg/ha

Present results showed that genotypes differed significantly (Table 2) in respect of nitrogen content (straw and grain), nitrogen uptake (straw, grain and total) and PNUE at maturity. Gambir 2, Tarabali and Balam showed significantly higher PNUE. Gambir 2 and Balam were top yielders and showed very consistent

Table 2. Performance of rice genotypes for nitrogen content (%), nitrogen uptake and physiological nitrogen use efficiency (PNUE) as influenced by different nutrient levels during T. *Aus*, 2003

Nutrient level	Nitrogen content (%)		Nitrogen uptake (Kg/ha)		Total uptake (Kg/ha)	PNUE (Kg grain Kg/N)
	Straw	Grain	Straw	Grain		
Goasail	0.92 ab	1.74 a	62.08 a	32.36 a	94.44 a	20.77 b
Balam	1.03 a	1.49 b	61.86 a	34.41 a	96.27 a	24.77 a
Tarabali	0.93 ab	1.27 c	47.67 b	24.88 b	72.55 b	27.24 a
Sada boro	0.73 c	1.47 b	54.37 ab	22.65 b	77.02 b	20.16 b
Gambir 2	0.90 b	1.46 b	58.65 a	34.91 a	93.57 a	26.81 a

Means followed by same common letter (s) are not differed significantly at 5 % level by DMRT

performance of nitrogen uptake and PNUE. Grain nitrogen content was higher than straw. Goasail ranked the top alone in respect of grain content. Rice genotypes were differentiated as efficient, inefficient and inferior types based on grain yield in relation to nitrogen supply (Singh *et al.,* 1998; Gourly *et al.,* 1993). Significant variations in nitrogen uptake, grain yield, nitrogen translocation efficiency and NUE among the varieties were also reported by Borrell *et al.*, 1998; Borah and Deka, 1994.

Traditional *Aus* rice cultivars showed significantly higher photosynthetic rate (Pn) in higher \nutrient level. Among the cultivars Gambir 2 produced highest Pn rate and Goasail was at the lowest. Goasail and Gambir 2 were considered to be efficient to utilize the low nitrogen level by demonstrating higher SPAD value. Traditional *Aus* rice cultivars demonstrated the ability of utilization of native nitrogen by showing significantly higher PNUE in no nutrient added condition.

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EFFECTS OF SOW NURSING AND PIGLETS SUCKLING BEHAVIOUR ON FARROWING TO WEANING LITTER WEIGHT

MIN PRASAD TIMSINA[1]

ABSTRACT

The effects of sow nursing and piglets suckling behaviour on total litter weight (TLW) from farrowing to weaning were investigated at commercial swine farm, Southern Thailand using 20 Landrace x Large White (LWLR) sows consisting of 10 sows each from Parity 2-3 and Parity 4-5. Individual behavioural parameters of sow with her litter were recorded through continuous visual observation and TLW were measured using weighing balance. The behavioural parameters such as nursing numbers, number of teats exposed, sow nursing grunts, piglets active at udder and nursing terminated by piglets had a significant effect ($P \leq 0.05$). The results were found highly positive correlated with TLW at 12 ± 1 hour after farrowing (TLW12) and a carry over effects on TLW 36 ± 1 hour after farrowing and TLW at weaning. On contrary, numbers of piglets missing nursing, nursing termination by sow and inter nursing interval were found highly negative correlated with TLW12. In general, Parity 4-5 sows raised and weaned heavy litters under commercial farm conditions. The effort should be made to encourage greater suckling frequency by providing good housing environments for sow and litter to maximize daily milk output in sow for subsequently weaning heavier litters.

Key words: Maternal behaviour, sow nursing, piglet suckling, total litter weight

INTRODUCTION

Maternal behaviour of sow is one of the important components of sow mothering ability as it has a large impact on the litter growth and their survival during the pre-weaning period (Grandinson, 2003). A sow with good maternal behaviour is expected to have better chance of weaning heavy litter at early stage. Valros (2003) suggested that since maternal behaviour plays a very important role in early litter

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growth, an increasing focus is needed on her ability to care more for her offspring. Similarly, the behaviour of sows during lactation is critical for early growth of their litters prior to weaning (Daza *et al*., 1999). Moreover, they further stated that proper coordination between sow and piglets during nursing are important for the litters to attain early total litter weight (TLW).

Grandinson (2003) confirmed that sow behaviour during lactation has a large influence on litter weight gain. He further stated that maternal behaviour has a large impact on litter performance and could be an important step towards improving sow productivity. A sow with good maternal behaviour is expected to nurse her litter frequently. Interestingly, Spinka *et al*. (1997) reported that frequency of milk ejections affects daily milk production in sow and litter suckling more frequently will ensure higher total milk intake. Similarly, high nursing frequency affects TLW positively due to higher frequency of milk ejection (Auldist *et al*., 2000; Valros *et al*., 2002). Hence, efficiency and ability of sow to raise large litter at early stage clearly reflects in its good nursing behaviour.

Till date very little publications are available and not much attention are given on the effects of sow nursing and piglet suckling behavioural parameters on TLW during early hours after farrowing. The first 12 to 36 hours after birth of piglets is considered to be the most critical period for the litter to get adequate care and attention of sow to attain early TLW. Thus, detailed understanding on sow nursing and piglets suckling behavioural parameters affecting early TLW and TLW at weaning have become very important. Therefore, this study was undertaken to assess the effects of sow nursing and piglets suckling behavioural parameters on early TLW (12 ± 1 hr and 36 ±1 hr) after farrowing and at weaning under commercial farm conditions.

MATERIALS AND METHODS

Selection of experimental animals

The study was conducted at Trang Wattana Farm (about 1,800 sows on farm), Southern Thailand, during the year 2006. Twenty LWLR sows were randomly selected and divided into 2 groups. Ten sows were in 2-3 parity and the others were in 4-5. The selected animals were in late pregnancy i.e. 1 to 2 days prior to farrowing. The sows that had long farrowing durations of more than four hours and farrowing process assisted by stockpersons were not included in the study.

Housing and management of sows and litters

The sows were kept in an intensive housing system of open building type with natural ventilation. They had an individual farrowing crate made of slatted floor

having floor space of 2.5 m x 2.0 m, which included the area for rearing the litters with creep box. Each shed had four big fans located at strategic points which provided ventilation in the shed. Water- drip cooling system on the shoulder of the sows was used to reduce heat stress and maintain their body temperature during hot weather. The sow had individual feeder and a nipple drinker with adequate access to drinking water. All sows were administered with synthetic Prostaglandin F2α one day before farrowing as a routine procedure. The antibiotics and antipyretic drugs were administered when they started farrowing and oxytocin was given once farrowing was over. On the day of farrowing, (Day 0), the sows were not given any feed but they had adequate access to drinking water. On Day 1, the sows were fed at 1 kg/sow/day and gradually increased up to 5 kg/sow/day until Day 5 after farrowing. From Day 6 onwards until weaning, all the sows were fed *ad libitum* at 6.30 am, 10.30 am, 3.30 pm and 8 pm.

The farm followed their routine vaccination program to all the experimental sows. The litter had an access to creep box with 100-Watt bulb hanging above the creep area to maintain temperature inside creep box. They also had access to creep feed from Day 10 after farrowing until weaning. The litters were weaned on an average of 24 ± 1 day after farrowing. The farm followed routine management practices in all litters. All sows in the lactation shed received same level of farm management practices.

Records on nursing and suckling behavioural parameters

Each sow with her litter was studied and observations made from the time of first nursing activity until 24 hours (hrs) for a period of 9 hrs. The observations were mainly on sow nursing and early piglets suckling behavioural parameters. The start of first nursing activity was described as the time the first piglet was born to an average 5-6 piglets found actively nursing at the udder. The 9 hrs observation period was divided into 3 parts i.e. morning (8 to 11 am), afternoon (1 to 4 pm) and night (6 to 9 pm). The individual behavioural parameters of sow with her litter were continuously recorded in each part for 3 hrs with 2 hrs gap in between. However, the observations during the day were attuned depending upon the feeding and other management system of the farm. Individual sow nursing and piglets suckling behavioural parameters are defined and presented in Table 1. All behavioural parameters were recorded through close visual observations by the same observer from behind the farrowing crates and entered in individual sow record sheet. The stopwatch was used to record the duration of nursing, nursing grunts and other time related parameters. The nursing duration was recorded only when it exceeded 60 seconds (Valros, 2003).

Table 1. Nursing and suckling behavioural parameters and their definitions

Behavioural parameters	Definitions
Nursing frequency	Number of occurrences of nursing activities during total observation time
Nursing duration	Time between start and end of each nursing activity
Start of nursing	Time when more than half of piglets are active at the udder, the sow lies in lateral posture, exposes her udder and starts characteristic nursing grunts
End of nursing	Time when more than half of the piglets leave the udder or remain inactive at the udder.
Duration of nursing grunts during nursing of sow	Short duration of nursing grunts of sow (≤ 30 seconds) and long duration of nursing grunts of sow (> 30 seconds) during each nursing within observation time
Teats exposed	Number of teats actually available for the piglets to suckle from total functional teats of the sow in each nursing
Nursing terminated by sow	Number of times when sow roll over on her belly to sitting or standing position preventing further udder massage or suckling by piglets
Piglets active at udder	Numbers of piglets actively massaging and suckling teats during nursing
Piglets missed nursing	Numbers of piglets not actively suckling teats but moving around sow despite teats being available to suckle
Nursing terminated by piglets	Number of times when more than half of the piglets leave the udder or remain motionless at the udder despite teats being accessible
Inter nursing interval	The time lap between the end of one nursing to the next

Performance parameters

TLW at 12 ± 1 hour (TLW12) and at 36 ± 1 hour (TLW36) after farrowing and TLW at weaning (TLWw) were recorded for each individual sow. TLW12 was recorded from the time the last piglet was born until 12 hrs. The weighing balance was used to record TLW by weighing of all live piglets within the same litter. The nursing behavioural parameters were recorded only within first 24 hrs from the start of first nursing activity, but the TLW were recorded both at 36 hrs after farrowing and at weaning. All experimental sows received the same level of farm management practices during the lactation period.

Experimental design and data analysis

The nursing behavioural parameters of sow with her litter were considered as main treatment effect. The traits considered for analysis were TLW12 and TLW36 and TLWw. The data were analyzed using Proc Correlation (Proc Corr) Procedure in Statistical Analysis System (Anonymous, 1999). The summarized results are presented in different tables as Means and Standard Deviations (SD) and correlation (r) for each nursing behavioural parameter affecting TLW of sows between parity with their corresponding r and P- values.

RESULTS AND DISCUSSION

Effect of nursing numbers on TLW

Nursing numbers had a significant effect and were found highly positive correlated with TLW12 ($r = 0.85$, $P < 0.01$) in Parity 2-3 sows and ($r = 0.86$, $P < 0.01$) in Parity 4-5 sows, respectively (Table 2). However, parity did not have a significant effect on nursing numbers during the observation period. Additionally, Figure 1 and 2 illustrated the correlation between number of nursing and TLW12 in parity 2-3 and parity 4-5 sows. The findings indicated that when the sow had more nursing numbers and nourished her litter frequently it had a positive effect on TLW12 and subsequently on TLWw. This could be mainly due to the fact that litter with larger nursing numbers suckling more frequently would intake more milk than the litter with lesser nursing numbers (Spinka *et al.*, 1997).

Table 2. Means ± SD and correlation between parity for number of nursings influencing on TLW (n =10)

Recording period	Parity number	Nursing numbers	TLW (kg)	r	P values
12 ± 1 h	2-3	13.50 ± 2.67	17.76 ± 2.20	0.85	0.010
36 ± 1 h	2-3	NR	20.06 ± 2.95	NA	NA
At wean	2-3	NR	73.60 ± 8.50	NA	NA
12 ± 1 h	4-5	15.20 ±1.03	19.42 ± 1.85	0.86	0.01
36 ± 1 h	4-5	NR	22.26 ± 2.08	NA	NA
At wean	4-5	NR	79.23 ± 7.82	NA	NA

NR = Not recorded; NA = Not applicable; SD = Standard Deviation; TLW = Total litter weight; n = Number of animals in each group; r = Correlation coefficient.

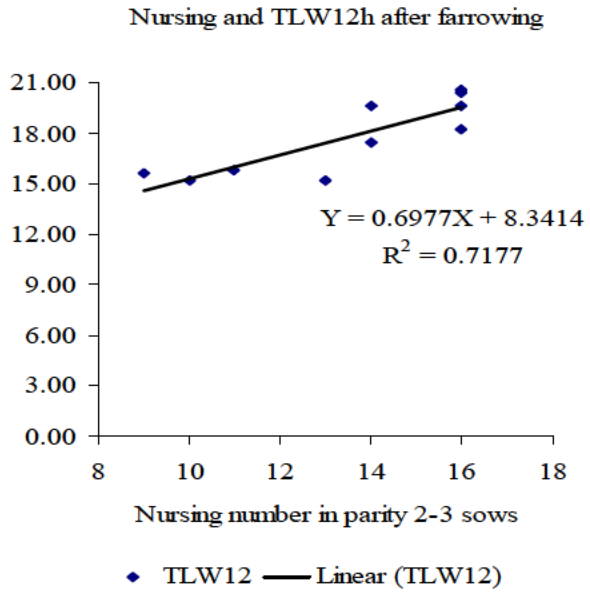

Figure 1. Correlation between nursing numbers and TLW12 in parity 2-3 sows

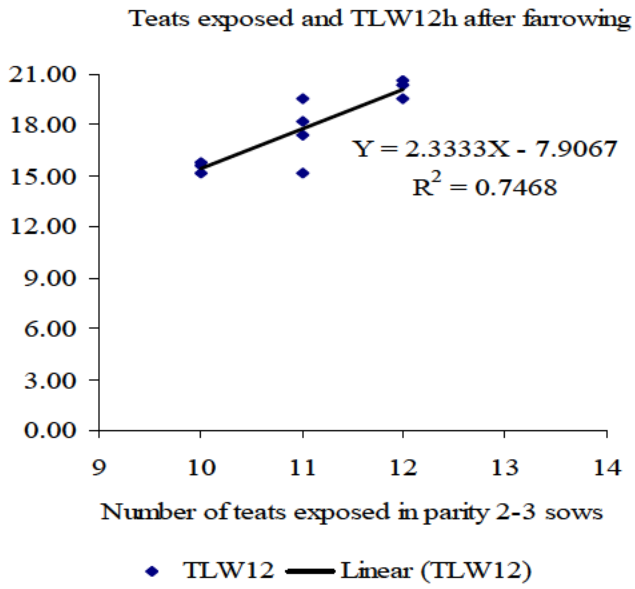

Figure 2. Correlation between number of teats exposed and TLW12 in parity 4-5 sows

The results showed TLW12 higher from Parity 4-5 sows than Parity 2-3 sows. The results were similar as Spinka *et al*. (1997) reported that piglets suckling more frequently would intake more milk. Interestingly, the piglets nursed with shorter inter nursing interval consumed 27 % more milk and gained 44 % more weight than litters with longer nursing interval.

In addition, Spinka *et al*. (1997) found that mean nursing numbers were 33.90 from sows nursing litters with shorter nursing interval compared to 20.20 from those sows nursing litters with longer nursing interval. In the present study, increase in nursing frequency with shorter inter nursing interval could have a positive correlation with TLW12, TLW36 and TLWw through increased milk production in sow. It was also possible that nursing frequency could be positively correlated to daily milk output in sows as litters tend to intake more milk in shorter inter nursing period (Spinka *et al*., 1997). The objective of the present study was to observe the effects of sow nursing and piglets suckling behavioural parameters on early TLW. The assessment on the effect of nursing frequency on mammary gland growth and daily milk output from sow was not within the scope of the present work. Moreover, Van den Brand *et al*. (2004) reported that nursing frequency was positively related with milk output. The finding in this study showed that Parity 4-5 sows raised heavier litters at early stage and subsequently weaned heavier litters compared to Parity 2-3 sows. The current study is in consistent with Auldist *et al*. (2000) and Valros *et al*. (2002) who confirmed a positive relationship between nursing frequency and average daily gain of piglets.

A low nursing motivation would probably decrease the nursing frequency, which would lower milk intake of piglets (Spinka *et al*., 1997; Valros *et al*., 2002). Therefore, sow nursing behaviour and her willingness to nurse all litters at the udders during each nursing period would determine daily milk output and TLW. The current study, found higher nursing frequency in Parity 4-5 sows and indicated that good nursing mothers showing better maternal characteristics would raise and wean heavier litters in sows.

Effect of functional teats exposed during nursing on TLW

Number of functional teats exposed during nursing had a significant effect and was found positively correlated with TLW12 ($r = 0.86$, $P < 0.01$) in Parity 2-3 sows and ($r = 0.69$, $P < 0.05$) in Parity 4-5 sows, respectively (Table 3). However, parity did not show any significant effect on number of teats exposed during observation periods. The correlation between number of teats exposed and TLW12 after farrowing in parity 2-3 and parity 4-5 sows are represented in Figure 3 and 4. When

higher numbers of teats were exposed during each nursing, the piglets got more access and choice to suckle and grow eventually to heavier litters.

The results of the present study were similar to English *et al.* (1977) who reported that many sows with good nursing behaviour were effective in exposing all functional teats of both upper and lower rows for their litters during suckling period which positively contributed to increased TLW. The ability of mother to expose all the functional teats during nursing with adequate milk secretion (English *et al*., 1977) and frequent nursing contributed to faster growth and higher survival of litter. Inability to expose all teats during nursing is more common in older sows than in gilts, which may seriously limit growth rate and chances of survival of piglets. Thus, the inability of sow to expose most of the functional teats would negatively effect on TLW (English *et al.*, 1977). Moreover, the sow with poor nursing behaviour were ineffective in exposing most of the posterior teats and nursed only a fewer number of piglets. In the present study, Parity 4-5 sows exposed more functional teats and showed good nursing behaviour compared to Parity 2-3 sows. Hence, good nursing behaviour and exposure of maximum number of functional teats during nursing were important parameters.

Table 3. Means ± SD and correlation between parity for number of teats exposed during nursing influencing on TLW (n = 10)

Recording period	Parity number	Number of teats exposed	TLW (kg)	r	P values
12 ± 1 h	2-3	11.00 ± 0.82	17.76 ± 2.20	0.86	0.01
36 ± 1 h	2-3	NR	20.06 ± 2.95	NA	NA
At wean	2-3	NR	73.60 ± 8.50	NA	NA
12 ± 1 h	4-5	11.50 ± 0.71	19.42 ± 1.85	0.69	0.05
36 ± 1 h	4-5	NR	22.26 ± 2.08	NA	NA
At wean	4-5	NR	79.23 ± 7.82	NA	NA

NR = Not recorded; NA = Not applicable; SD = Standard Deviation; TLW = Total litter weight;

n = Number of animals in each group; r = Correlation coefficient.

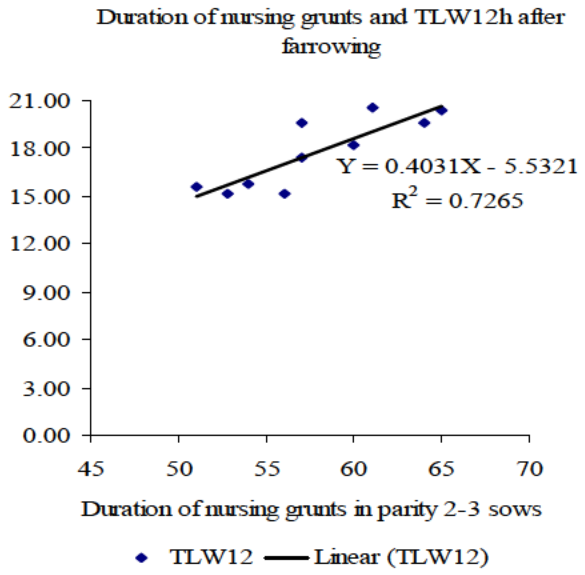

Figure 3. Correlation between duration of nursing grunts during nursing of sows and TLW12 in parity 2-3 sows

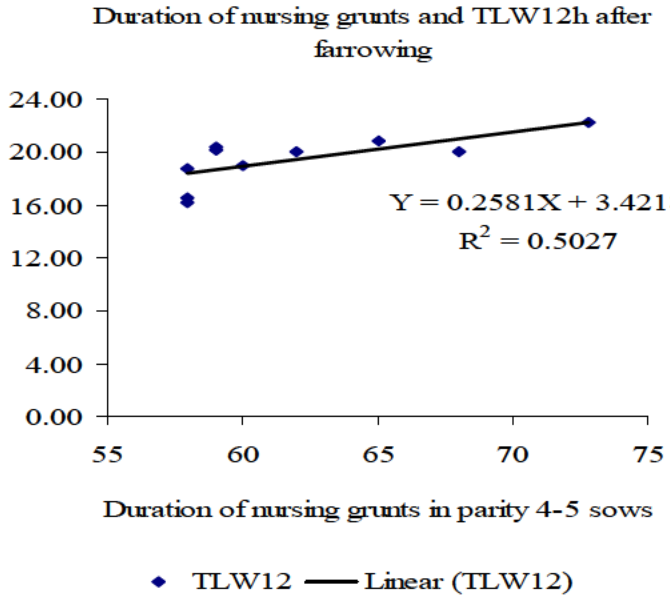

Figure 4. Correlation between duration of nursing grunts during nursing of sows and TLW12 in parity 4-5 sows

Effect of nursing grunts during nursing of sows on TLW

Duration of nursing grunts during nursing of sows had a significant effect and was found highly positively correlated with TLW12 ($r = 0.85$, $P < 0.01$) in Parity 2-3 sows and ($r = 0.71$, $P < 0.05$) in Parity 4-5 sows (Table 4). However, parity did not significantly influence on duration of nursing grunts during the observation period. Further, Figure 5 and 6 illustrates the correlation between duration of nursing grunts during nursing of sows and TLW12 in parity 2-3 and parity 4-5 sows. The current findings showed that duration of nursing grunts of sows was found positively correlated with early TLW and subsequently weaning heavier litter. The grunting duration of sow could be related to oxytocin release to exert intra mammary pressure resulting into milk ejection which may be positively correlated with TLW (Algers *et al*., 1990).

Table 4. Means ± SD and correlation between parity for duration of nursing grunts during nursing of sows influencing on TLW (n = 10)

Recording period	Parity number	Duration of nursing grunts (seconds)	TLW (kg)	r	P values
12 ± 1 h	2-3	57.80 ± 4.64	17.76 ± 2.20	0.85	0.01
36 ± 1 h	2-3	NR	20.06 ± 2.95	NA	NA
At wean	2-3	NR	73.60 ± 8.50	NA	NA
12 ± 1 h	4-5	62.00 ± 5.12	19.42 ± 1.85	0.71	0.05
36 ± 1 h	4-5	NR	22.26 ± 2.08	NA	NA
At wean	4-5	NR	79.23 ± 7.82	NA	NA

NR = Not recorded; NA = Not applicable; SD = Standard Deviation; TLW = Total litter weight; n = Number of animals in each group; r = Correlation coefficient.

Similarly, Algers *et al*. (1990) also suggested that when sow-nursing grunts is of longer duration, it is believed and expected that litters get more time to draw milk from teats with longer duration of milk ejection through increased flow of oxytocin into mammary gland. The results of current studies are similar to some extent with Algers *et al*. (1990) who reported that size of grunting peak was positively correlated with the amount of oxytocin released. The function of grunting of sow was to alert and attract piglets to the udder for suckling. In the current studies, longer duration of nursing grunts of sow provided better opportunity for almost all the piglets to assemble and suck teats. The nursing grunts of sow and milk ejection time through increased oxytocin release was predicted more in Parity 4-5 sows than in Parity 2-3 sows. Since Parity 4-5 sows were considered as mature and experienced mother with better maternal characteristics, they provided longer duration of nursing grunts to enable litter intake more milk from teats and gain weight compared to Parity 2-3 sows.

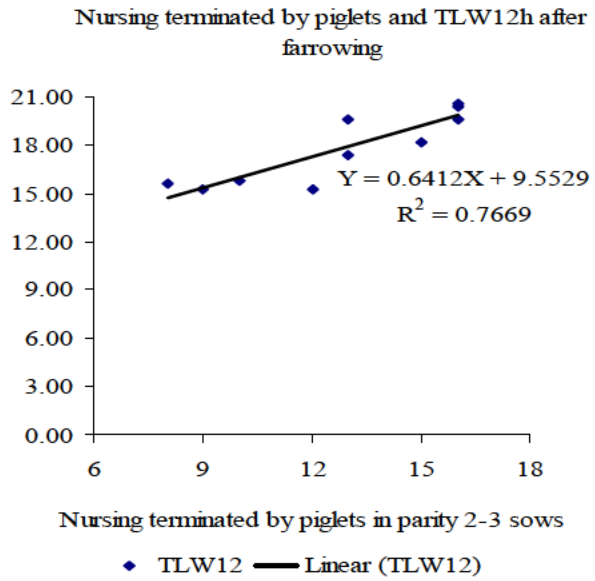

Figure 5. Correlation between numbers of nursings terminated by piglets and TLW12 in parity 2-3 sows

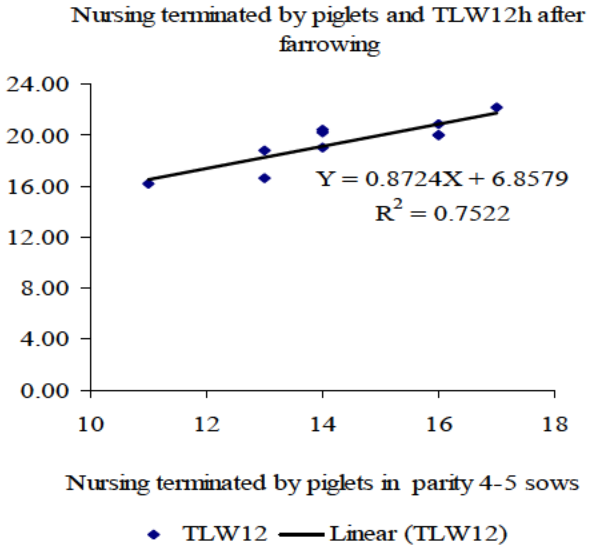

Figure 6. Correlation between numbers of nursings terminated by piglets and TLW12 in parity 4-5 sows

It is important that the piglets are able to start suckling as soon as milk is available, because a 5 seconds delay will cause a 25-50 % loss of milk release from sow (Ellendorff *et al*., 1982). Moreover, milk available to the piglets is only approximately 10 to 20 seconds (Fraser 1980) after oxytocin causes the contraction of the myo-epithelial cells in the udder (Ellendorff *et al*., 1982). In the present studies, the litters from Parity 4-5 sows could have drained more milk because of higher peak in grunting frequency and longer duration of nursing grunts through increased flow of oxytocin for attaining early TLW and heavier TLW at wean.

Effect of piglets active at udder during nursing on TLW

Number of piglets active at the udder during nursing had a significant effect and was found positively correlated with TLW12 ($r = 0.86$, $P < 0.01$) in Parity 2-3 sows and ($r = 0.73$, $P < 0.01$) in Parity 4-5 sows (Table 5). However, parity did not have significant effect on number of piglets active at udder during the observation period. The number of piglets active at udder was found positively correlated with TLW12. It was possible that when more piglets are active at udder during nursing, it had a strong and positive effect on early TLW. This could be because when more piglets were found actively nursing at udder they tended to draw more milk collectively which would positively contribute to increased TLW. In contrast, when more piglets missed nursing during each suckling bout it had a negative effect on early TLW. In the current studies, no piglets were found missing nursing at the udder from Parity 4-5 sows when some piglets missed their nursings from Parity 2-3 sows. This could be the reason for Parity 4-5 sows to raise heavier litters at early stage compared to Parity 2-3 sows.

Table 5. Means ± SD and correlation between parity for number of piglets active at the udder influencing on TLW (n = 10)

Recording period	Parity number	Piglets active at udder (heads)	TLW (kg)	r	P values
12 ± 1 h	2-3	11.00 ± 0.82	17.76 ± 2.20	0.86	0.01
36 ± 1 h	2-3	NR	20.06 ± 2.95	NA	NA
At wean	2-3	NR	73.60 ± 8.50	NA	NA
12 ± 1 h	4-5	11.10 ± 0.87	19.42 ± 1.85	0.73	0.01
36 ± 1 h	4-5	NR	22.26 ± 2.08	NA	NA
At wean	4-5	NR	79.23 ± 7.82	NA	NA

NR = Not recorded; NA = Not applicable; SD = Standard Deviation; TLW = Total litter weight;
n = Number of animals in each group; r = Correlation coefficient.

Effect of nursings terminated by piglets on TLW

Number of nursings terminated by piglets had a significant effect and was found positively correlated with TLW12 (r = 0.87, P <0.01) in Parity 2-3 sows and (r= 0.88, P <0.01) in Parity 4-5 sows (Table 6). However, parity did not have significant effect on number of nursing terminated by piglets during the observation period. Besides, Figure 7 and 8 represents the correlation between number of nursings terminated by piglets and TLW12 after farrowing in parity 2-3 and parity 4-5 sows. The study showed that nursing terminated by piglets was positively correlated with TLW12. However, a negative correlation existed between nursing terminated by sows with TLW12. The study confirmed that when more numbers of nursing are terminated by piglets compared to nursing terminated by sows, it had a positive effect on early TLW. When piglets terminated more nursing it indicated their satisfaction in drawing complete milk from the udder during nursing episode (Fraser 1980). On contrary, when a sow terminated more nursing, it was usually considered as the sign of her rejection, not showing good maternal characteristics or adequate attention to piglets at nursing (Valros, 2003). In the later situation, the piglets would not get full satisfaction with their suckling activity and subsequently had a negative effect on TLW (Fraser 1980). In general, the studies confirmed that Parity 4-5 sows raised and weaned heavy litters compared to Parity 2-3 sows under on farm housing and management practices.

Table 6. Means ± SD and correlation between parity for number of nursings terminated by piglets influencing on TLW (n = 10)

Recording period	Parity number	Number of nursings terminated by piglets	TLW (kg)	r	P values
12 ± 1 h	2-3	12.80 ± 3.01	17.76 ± 2.20	0.87	0.01
36 ± 1 h	2-3	NR	20.06 ± 2.95	NA	NA
At wean	2-3	NR	73.60 ± 8.50	NA	NA
12 ± 1 h	4-5	14.40 ± 1.83	19.42 ± 1.85	0.88	0.01
36 ± 1 h	4-5	NR	22.26 ± 2.08	NA	NA
At wean	4-5	NR	79.23 ± 7.82	NA	NA

NR = Not recorded; NA = Not applicable; SD = Standard Deviation; TLW = Total litter weight; n = Number of animals in each group; r = Correlation coefficient.

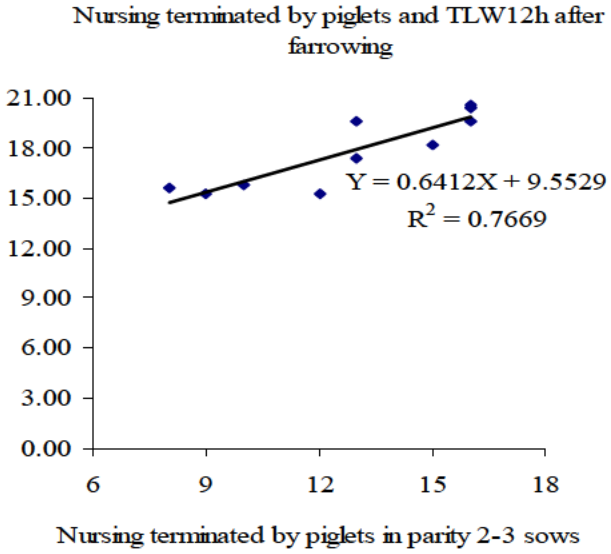

Figure 7. Correlation between numbers of nursings terminated by piglets and TLW12 in parity 2-3 sows

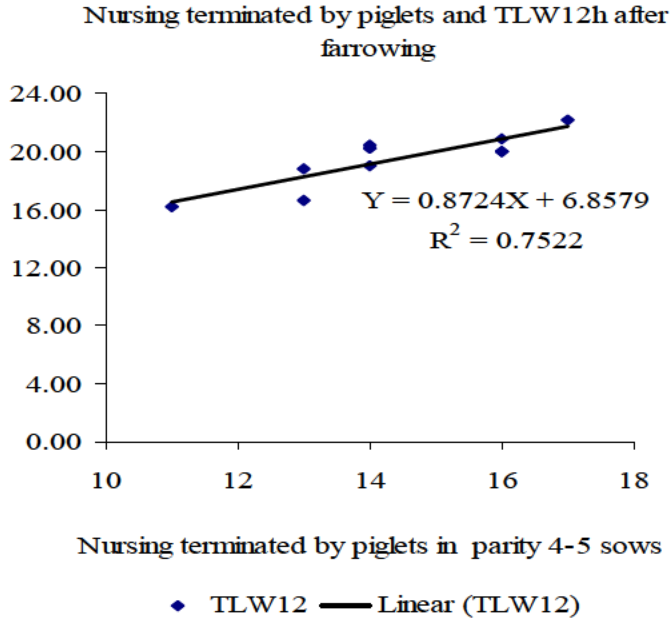

Figure 8. Correlation between numbers of nursings terminated by piglets and TLW12 in parity 4-5 sows

Since the present study was an on-farm experiment without disturbing the ongoing management system, the findings would have a better application. However, some of these findings would require cautious applications as the behavioural parameters were studied through continuous visual observations. It was found more practicable than other approaches under present circumstances. For this reason, some of the current findings might differ if similar experiment was carried out using different approach and in particular under controlled station conditions. Thus, it warrant further investigation and deeper understanding through video recording to capture wider picture on some of the detailed nursing behavioural parameters influencing early TLW.

The behavioural parameters such nursing numbers, number of functional teat exposed during nursing, duration of sow nursing grunts, number of piglets active at udder and nursing terminated by piglets had significant effect and positive correlation with TLW12. It also had correlation carried over effect on TLW36 and TLWw. On contrary, piglets missing nursing, nursing terminated by sow and sow nursing intervals showed negative correlation with TLW12. Parity 4-5 sows raised and weaned heavy litters compared to Parity 2-3 sows under commercial farm conditions. Further studies were required to assess the effects of increased nursing frequency on mammary gland growth and milk production in sow and other nursing behavioural parameters through video recording to capture wider pictures as they are considered fundamental for TLW gain in piglets. Efforts should also be made to minimize the disturbance of communication between sow and litter and encourage greater suckling frequency by providing good housing environments for sow and litter to maximize daily milk output in sow and wean heavier litters at early stage.

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BIO-INTENSIVE INTEGRATED MODULE FOR THE MANAGEMENT OF TOBACCO APHID (*Myzus nicotianae Blackman*) IN INDIA

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ABSTRACT

Tobacco aphid, *Myzus nicotianae*, is the major pest of tobacco crop in Karnataka light soils. Though effective chemical control measures are available, investigations were conducted to evolve a bio-intensive IPM module with use of chemical active ingredients. Three crops viz., Bajra, Sorghum and Maize were evaluated as barrier crops separately around the tobacco crop in a replicated trial for three consecutive years (2002-05). Bajra or Sorghum as barrier crop with one spray of imidacloprid @ 50 g a.i/ha at 50 days after planting was effective in significantly reducing the aphid infestation (>95%). The border crops also harboured several natural predators like coccinellids, spiders, wasps in varying numbers, while *Nesidiocoris* was more in number on tobacco crop surrounded by the barrier crops and without any chemical spray. The treatments with barrier crop + one spray of chemical also avoid effected 100% and control higher and lower of sooty mold and significant control of virus diseases resulting in higher bright grade yield (1176-1231 kg/ha as against only 604 kg/ha in check plots). The bio-intensive module of barrier crops surrounding tobacco crop effectively checked the aphid infestation (57-64%), while the chemical control module involving rotation of sprays with imidacloprid and acephate required a minimum of two sprays for significant reduction of aphid populations.

Keywords: Tobacco, *Myzus nicotianae*, Border crops, BIPM.

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INTRODUCTION

Tobacco aphid, *Myzus nicotianae* Blackman is the major pest on tobacco crop in Karnataka light soil region. Winged forms of aphid also act as vectors for some virus diseases. This insect causes de-sapping and honeydew secretion leading to significant yield losses (Mistric and Clark, 1979). Sooty mold developed by *Fumgo vagans*, due to honeydew secretion of aphid feeding, renders leaf unfit for curing and causes a huge loss. Several pesticides were even though found effective in controlling aphid infestation. (Semtner *et al*., 1990 and Nagalaksmi, 1994), but efforts were made to reduce the pesticide uses through integrated approach. Studies were conducted to evaluate effectiveness of border crops in managing the aphid pest through providing shelter for natural predators in the crop ecosystem.

MATERIALS AND METHODS

A field trial was conducted at CTRI Research Station, Hunsur, during 2002-05, to evaluate bajra, sorghum and maize as border crops for the management of tobacco aphid, *Myzus nicotianae*. Three modules viz., bio, bio + chemical and chemical module were tested involving above barrier crops for enhancement of arthropod predators and prevention of aphid infestation in Flue Cured Virginia tobacco var. Kanchan (NLS-4). The treatments consisted of three border crops alone and border crops with one spray of imidacloprid @ 50 g a.i./ha at 50 days after planting (DAP). One chemical control plot was also maintained with one spray of imidacloprid @ 50 g a.i./ha at 40 DAP and one spray of acephate @ 750 g a.i./ha at 60 DAP. One unsprayed plot was also maintained without any border crop for comparison. Border crops in three rows with 30 cm spacing were sown just before planting of tobacco. All other recommended practices were followed (Shenoi, 1998) to raise the crop. Observations on aphid infested plants; natural enemy predators, sooty mold incidence and viral diseases were recorded at regular intervals. Aphid populations were recorded on five randomly selected plants in each plot following the method of Karla and Gupta (1986) improved by Sreedhar *et al*., (1993). Various yield parameters viz., green leaf, bright grade, medium grade, low grade and total cured leaf were also recorded. Data recorded for all three consecutive years were pooled and analyzed statistically.

RESULTS AND DISCUSSION

Aphid infestation: Except maize border, all the remaining treatments were significantly superior in reducing aphid infestation over control (Table 1). However, border crops in combination with one spray of imidacloprid were significantly

superior over border crops alone. In chemical control plot (imidacloprid + acephate), the aphid infested plants were 1.42%, which was at par with border crops with one spray of imidacloprid. Maximum aphid infested plants (21.74%) were recorded in unsprayed plot (tobacco sole crop) followed by maize border (16.77%), bajra border (9.22%) and sorghum border (7.61%). Highest percent reduction (98.48) of aphid-infested plants over control was recorded in sorghum border with one spray of imidacloprid followed by bajra border with imidacloprid spray (97.65), maize border with imidacloprid spray (96.09) and chemical control (93.46). Border crops alone prevented aphid infestation from 22.86 to 64.99% over control.

Table 1. Effect of barrier crops on the incidence of tobacco aphid, *Myzus nicotianae* (Pooled data of 2002-03 to 2004-05)

Sl. No.	Treatments	Mean per cent plants infested by aphids	Mean per cent reduction of aphid infested plants over control
1	Sorghum border	7.61 (16.00)	64.99
2	Maize border	16.77 (24.16)	22.86
3	Bajra border	9.22 (17.66)	57.58
4	Sorghum border + One spray imidacloprid	0.33 (3.31)	98.48
5	Maize border + One spray imidacloprid	0.85 (5.27)	96.09
6.	Bajra border + One spray imidacloprid	0.51 (4.07)	97.65
7	One spray imidacloprid + One spray acephate	1.42 (6.83)	93.46
8	Tobacco sole crop (no border & no spray) – check	21.74 (27.77)	-

	S.Em.±	CD (5%)	CV (%)
Seasons	1.22	0.00	45.61
Treatments	2.60	7.21	59.41
Interaction	4.51	0.00	-

Figures in parentheses are arc sin transformed values

Aphid population

The aphid population counted on infested plants in each treatment showed similar trend (Table 2). Based on aphid population, score was given from 0 to 5 for top, middle and bottom leaves of five infested plants in each plot. Aphid population was more on top leaves followed by middle and bottom leaves. The population was nil on middle and bottom leaves of bajra border with one spray of imidacloprid. In chemical control plot as well as border crops with one spray of imidacloprid, the aphid population score recorded was below 1.0. In control plot, high population scores of 3.98, 3.18 and 2.72 were recorded on top, middle and bottom leaves respectively. Aphid population was also high in maize border treatment with 2.45, 1.56 and 1.11 scores on top, middle and bottom leaves followed by sorghum and bajra border crops with mean aphid population scores of 2.29, 1.36,0.83 and 2.03, 1.25, 0.72 respectively.

Table 2. Aphid population in different treatments (Pooled data of 2002-03 to 2004-05)

Sl. No.	Treatments	Mean aphid population (Score)		
		Top leaf	Middle leaf	Bottom leaf
1	Sorghum border	2.29	1.36	0.83
2	Maize border	2.45	1.56	1.11
3	Bajra border	2.03	1.25	0.72
4	Sorghum border + One spray imidacloprid	0.15	0.02	0.02
5.	Maize border + One spray imidacloprid	0.51	0.13	0.11
6.	Bajra border + One spray imidacloprid	0.21	0.00	0.00
7.	One spray imidacloprid + One spray acephate	1.53	0.91	0.57
8	Tobacco sole crop-check (no border & no spray)	3.98	3.18	2.72

Score: 1, 2, 3, 4, 5, 6, corresponding to aphid population 0, 1-50, 51-250, 251-500, 501-1000 and above 1000

Natural enemy population

The treatments with spray schedules showed drastic reduction in the population of natural enemies in tobacco crop. Maximum predator population (22.02/plant) was recorded on tobacco sole crop (control) followed by tobacco crop

with maize border (19.16), sorghum border (18.14) and bajra border sorghum (17.99). In sprayed plots, the predator population on tobacco was very less and ranged from 3.70 to 5.00/plant.

The highest number of coccinellids (2.05 and 1.85/plant) were recorded on sorghum border followed by bajra (1.18 and 1.87) and maize (1.52 and 1.49) in both unsprayed and sprayed conditions. There was no much difference in population of spiders and wasps between three barrier crops of both unsprayed and sprayed plots and their population ranged between 0.87 to 1.18 and 0.56 to 0.79/plant, respectively. Total predator population (tobacco + border crop) was more (4.91/plant) in maize border followed by sorghum border with one spray (4.87), sorghum border with no spray (4.72), bajra border with one spray (4.71), maize border with one spray (4.34) and bajra border (3.89) with no spray (Table 3).

Table 3. Mean population of natural enemies on tobacco crop and border crops (Pooled data of 2002-03 to 2004-05)

Sl. No.	Treatments	Population/plant (tobacco)				Population/plant (Border)						
		Nesidi-ocoris	Cocci-nellids	Others	Total	Cocci-nellids	Spiders	Wasps	Syrphid files	Dragon files	Damsel files	M b
1	Jowar border	17.30	0.45	0.37	18.14	2.05	1.01	0.58	0.38	0.28	0.25	0
2	Maize border	17.90	0.67	0.57	19.16	1.52	1.07	0.76	0.45	0.48	0.48	0
3	Bajra border	16.96	0.65	0.41	17.99	1.18	0.87	0.56	0.61	0.25	0.25	0
4	Jowar border + 1 spray imidacloprid	4.36	0.31	0.33	5.00	1.85	1.18	0.65	0.48	0.23	0.23	0
5	Maize border + 1 spray imidacloprid	3.91	0.42	0.39	4.72	1.49	0.96	0.79	0.45	0.35	0.17	0
6	Bajra border + 1 spray imidacloprid	3.63	0.18	0.27	4.09	1.87	0.96	0.65	0.46	0.40	0.17	0
7	1 spray imidacloprid + 1 spray acephate	3.28	0.27	0.14	3.70	-	-	-	-	-	-	
8	Tobacco sole crop (no border & no spray) – check	19.78	1.33	0.90	22.02	-	-	-	-	-	-	

Sooty mold and viral diseases

Treatments having border crops + one spray of imidacloprid were highly significant for 100% reduction of sooty mold incidence, while incidence of sooty mold in treatments having only border crops was low to medium (Table 4). In control plot, sooty mold incidences percent were 33.75, 28.04 and 18.22% respectively. Similarly, all the treatments showed significant reduction of viral diseases transmitted by aphids. The incidence of Bushy Top and Rosette ranged from 1.76 to 4.88% in treatments with border + chemical as against 4.83 & 12.57% in chemical module and check, respectively.

Table 4. Incidence of sooty mold and viral diseases in different treatments (Pooled data of 2002-03 to 2004-05)

Sl. No.	Treatments	Sooty mold (%)			Rosette and Bushy Top virus (%)
		Low	Medium	High	
1	Sorghum border	26.68 (31.08)	7.30 (15.66)	0.00 (0.00)	3.20 (10.30)
2	Maize border	12.40 (20.60)	8.57 (17.01)	3.34 (10.53)	4.88 (12.75)
3	Bajra border	7.49 (15.87)	0.19 (2.48)	1.21 (6.30)	3.27 (10.41)
4	Sorghum border + One spray imidacloprid	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.60 (9.27)
5.	Maize border + One spray imidacloprid	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.21 (10.31)
6	Bajra border + One spray imidacloprid	0.00 (0.00)	0.0 (0.00)	0.00 (0.00)	4.83 (12.68)
7.	One spray imidacloprid + One spray acephate	0.00 (0.00)	0.0 (0.00)	0.00 (0.00)	4.83 (12.68)
8	Tobacco sole crop-check (no border & no spray)	33.75 (35.50)	28.04 (31.96)	18.22 (25.25)	12.57 (20.75)
Figures in parentheses are arc sin transformed values					
	Seasons				
	S. Em.±	0.37	0.48	1.44	0.40
	CV (%)	14.19	28.20	133.65	16.85
	Treatments				
	S. Em.±	1.92	1.33	2.28	1.28
	C.D. at 5%	5.57	3.85	6.60	3.70
	CV (%)	36.55	38.84	106.12	26.60
	Interaction				
	S.Em. ±	2.72	1.88	3.22	1.81

Yield

Yields were significantly more in chemical control plot and plots surrounded by barrier crops with one spray of imidacloprid 50g a.i./ha over tobacco sole crop (Table 5). Whereas, barrier crops alone have not increased green leaf yields over control plot except bright leaf and total cured leaf yields. Except sorghum border, bright leaf yields were significantly superior in all the remaining treatments over control. Maximum bright leaf of 1231 kg/ha was recorded in sorghum border with one spray of imidacloprid. The significant control of aphid infestation, sooty mold and virus diseases was reflected in bright grade yields of tobacco. Lowest yields of 11369, 1291 and 604 kg/ha of green leaf, total cured leaf and bright leaf, respectively were recorded in control plot (no border & no chemical). Regarding low and medium grades, there was no significant difference among the treatments.

The present findings are in conformity with the studies conducted by Difonzo *et al*. (1996). They have reported that soybean was the most preferred crop to use as a border to potato because it was not a host for aphids or potato viruses. Sorghum and wheat also worked well as borders. Alate (winged) aphids are recognized as playing a significant role in PVY spread in many potato growing areas of world. Generally, wind currents spread aphids in large numbers. In such case, border crops act as barriers to trap the aphids and prevent their spread. They also reported that border crop of sunflower significantly reduced PVY spread to pepper transmission crop. Aphids landed and fed on the border crop transmit virus to the non-host crop. Border crop filtered PVY from aphid mouth parts. Border crops also reduced pest populations by facilitating predation rates and reducing movement rate of pests out of crop fields (Fahrig and Jonsen, 1998; Bhar and Fahrig, 1998). Mostly, woody borders provide habitat for many natural enemies that would otherwise not be found in agricultural crops.

Inter/border cropping system was found to be the best in reducing the shoot damage ranging from 49.85 to 98.76%. In New England, Connecticut growers who used “Blue Hubbard” as a perimeter trap crop to protect summer squash plantings found that the system succeeded in improving and simplifying pest management while providing numerous hidden benefits (Boucher and Durgy, 2004). These growers reduced insecticide use by 93% by switching to a perimeter trap crop, supplemented with border sprays. The technology was inexpensive, accessible and applicable to farm operations with on multiple crops.

From the present study, it was revealed that if aphid incidence was less (below 10%), border crops alone could prevent the infestation on tobacco. In case of severe infestation, barrier crops in combination with one spray of imidacloprid 50 g a.i./ha at 50 days after planting would manage the aphid problem in Karnataka light soil tobacco.

Table 5. Yield data of tobacco (kg/ha) in different treatments (Pooled data of 2002-03 to 2004-05)

Sl. No.	Treatments	Green leaf	Bright grade	Medium grade	Low grade	Total cured
1	Jowar border	12495	842	337	212	1382
2	Maize border	12747	917	416	250	1673
3	Bajra border	11951	998	392	213	1613
4	Jowar border + 1 spray imidacloprid	12957	1231	395	183	1809
5	Maize border + 1 spray imidacloprid	13737	1057	393	179	1629
6	Bajra border + 1 spray imidacloprid	14565	1176	355	196	1749
7	1 spray imidacloprid + 1 spray acephate	13555	898	367	179	1444
8	Tobacco sole crop – check (no border & no spray)	11369	604	348	227	1291
	Seasons					
	S.Em.±	463.99	71.56	24.08	20.77	64.40
	C.D. at 5%	1605.67	247.65	0.00	0.00	222.86
	CV (%)	17.59	36.32	32.43	49.67	20.05
	Treatments					
	S.Em.±	530.81	59.41	24.73	21.79	76.34
	C.D. at 5%	1471.31	164.66	0.00	0.00	211.59
	CV (%)	12.32	18.46	1977	31.91	14.55
	Interaction					
	S.Em.±	919.40	102.89	42.83	37.74	132.22
	CD at 5%	2548.38	285 20	0.00	0.00	0.00

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EFFECT OF DIFFERENT TREATMENTS ON GERMINATION BEHAVIOUR OF HENNA (*Lawsonia inermis* L.) SEEDS

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ABSTRACT

The present study was made to assess the effect of different treatments on germination behaviour of henna (*Lawsonia inermis* L.) seeds. Four-month old seeds were treated with Sand scarification (10 min.), Water soaking (72 hrs.), H_2SO_4 -10% (30 min.), HCl -10% (30 min.), NaCl -5% (24 hrs.), KCl -5% (24 hrs.), $CaCl_2$ -1.0% (24 hrs.). Untreated seeds were taken as control. Germination per cent, days taken to initiate and complete the germination, length of seedling, weight of fresh and dried seedlings and vigour indices of seedlings were recorded in the experiment. These characteristics were influenced significantly by different treatments. Among the treatments NaCl (5%) proved to be more effective for maintaining higher values of the above parameters followed by water soaking (72 hours) and sand scarification (10 min) treatments. The seed treatment with H_2SO_4 (10 %) and HCl (10%) for 30 min influenced negatively the germination behaviour, which might be due to over scarification of treated seeds

Key words: Henna (*Lawsonia inermis* L.), seed treatment, germination behaviour, vigour indices

INTRODUCTION

Henna (*Lawsonia inermis* L.), commonly known as 'Mehndi', belongs to family Lythraceae. It is a shrub or small tree about 2-7 m tall and is cultivated in many tropical and warm temperature regions as hedge plant. Large scale cultivation

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for its use as dye is mainly confined to India, Egypt, Sudan, Persia, Madagascar, Pakistan and Australia. In India it is grown as hedge plant throughout the country. As a commercial dye crop it was grown mainly in Rajasthan, Punjab, Gujarat and Madhya Pradesh States, about 50 years ago (Anonymous, 1962). At present, major areas of cultivation is in Sojat and Marwar Junction region of Pali district of Rajasthan and in some pockets of Gujarat. It occupied about 40,000 ha of field, hedge, bunds and gardens in India and produced about 35,000 tonnes in 2003-04 (Singh *et al*., 2005).

Henna has long been used as cosmetic and medicine (Ghosh, 1999; Kumar and Gopal, 1999) in India and Middle-East countries for colouring palms, hands, soles of feet and finger nails and for dyeing hair, beard and eyebrows for personal adornment. It is also used for dyeing textile, silk, wool, leathers and skins. Its leaf powder and oil have significant curing effect on diseases caused by bacteria, fungi and parasitic nematodes (Korayem and Osman, 1992; Singh and Singh, 1997; Satish and Raveesha, 1999). Its flowers are used in perfumery. Otto of henna or 'heena attar' (scent) is traditionally produced by steam distillation of crushed flowers. Its fragrant nature is due to beta-ionone. Egyptians used henna more for its medicinal uses. Now-a-days is used more as cosmetics and perfumes.

Propagation of henna is done mainly by seeds for commercial cultivation and by cuttings for hedge plantation. Henna seeds are straw to dark brown, small (1-2 mm long), hard and wedge-shaped. They are borne in small globular capsules exhibiting sometimes polymorphism in size. The seeds have a xeromorphic structure. Germination rate is affected by the length of storage and depth of sowing.

Seeds sown at 2.5 cm deep in soil did not germinate (Bukin, 1983). Its seeds are hardy and require soaking in water to facilitate germination (Miczak, 2001). For better germination seeds are to be sown on soil surface after water soaking for 20-25 days (Anonymous, 1962). Henna propagation through seedlings is preferred for field planting due to their higher survival rate and economy. Henna seeds have a hard coat and take a lot of time to germinate with less than 20 % germination. Higher germination was obtained under favourable temperature (25 - 30^{o} C) and humid conditions in shade as compared to those sown in open (Singh *et al*., 2005). Therefore, the present investigation was carried out in laboratory conditions to study the effect of different treatments on time and rate of seed germination seedling vigour, fresh and dry weight of seedlings.

MATERIALS AND METHODS

The experiment was conducted under laboratory conditions in petridishes of 10 cm diameter at Central Arid Zone Research Institute, Regional Research Station, Pali-Marwar, India, in March 2003 and March 2004. Healthy dry seeds (about 4 months old) of henna (*Lawsonia inermis L.*) cv. Sojat local were procured from experimental farm of the station. The seeds were then subjected to different treatments viz., untreated control (T_1), sand scarification of dry seeds for 10 min (T_2), water soaking for 72 hours (T_3), H_2SO_4 (10%) for 30 min (T_4), HCl (10%) for 30 min (T_5), NaCl (5%) for 24 hours (T_6), KCl (5%) for 24 hours (T_7) and $CaCl_2$ (1%) for 24 hours (T_8). The seeds after treatments were placed on water saturated blotting papers inside petridishes. Water was sprayed twice in a day in the petridishes to maintain humidity during experimentation. The petridishes were placed at ambient conditions in the laboratory. The mean maximum temperature was 30 ± 2^o C and the mean minimum temperature was 15 ± 2^o C. The average relative humidity was 57 + 2.5 %.

Seeds germination was studied as per ISTA (1993) procedures. One hundred seeds per replicate were used. Ten seedlings from each replicate were randomly removed after 15 days of seed placement inside petridishes for measurement of length (root and shoot) and weight (fresh and dry). Dry weight was recorded after drying at 65^o C for 48 hours. Seedling vigour was compared by means of vigour indices I and II calculated by multiplying percentage germination with seedling length and dry weight, respectively (Abdul-Baki and Anderson, 1973). The petridishes were arranged in complete randomized design (CRD) with three replications. Data were analyzed statistically. Significance of difference among the treatment means was tested by Student's *t* test at 5 % level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Results showed that different treatments influenced significantly the germination percent, number of days taken to initiate and complete the germination (Table 1). The mean highest percentage of germination (72.71 %) was recorded with NaCl treatment followed by water soaking (68.83 %) and sand scarification (63.83 %) treatment compared to control (46.96 %). The lowest mean germination (43.9%) was obtained from H_2So_4 treated solution. Similarly the application of different treatments improved the germination speed as compared to control. On average the minimum numbers of days were taken to initiate (5.66) and to complete (10.16) the germination of seeds treated with NaCl followed by water soaking treatment. The germination speed was recorded lowest in untreated seeds where the germination was

initiated after 7.83 days and completed after 13.00 days of placement of seeds in petridishes.

Table 1. Effect of different treatments on germination (%) and number of days taken to initiate and complete the germination

Treatment	Germination per cent			No. of days taken to initiate the germination			No. of days taken to complete the germination		
	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
T_{1}- Control	50.50	43.43	46.96	6.67	9.00	7.83	12.33	13.67	13.00
T_{2}- Sand scarification	64.87	62.80	63.83	5.33	7.67	6.50	11.00	12.33	11.66
T_{3}- Water soaking	69.94	67.72	68.83	6.00	6.33	6.16	10.00	11.33	10.66
T_{4}- H_2SO_4 (10%)	38.63	37.18	37.90	6.00	7.67	6.83	11.33	12.67	12.00
T_{5}- HCl (10%)	44.84	41.79	43.31	6.00	9.00	7.50	11.33	12.67	12.00
T_{6}- NaCl (5%)	75.43	70.00	72.71	5.33	6.00	5.66	9.33	11.00	10.16
T_{7}- KCl (5%)	60.45	56.93	58.69	5.66	7.00	6.33	10.67	13.00	11.83
T_{8}- $CaCl_2$ (1%)	62.72	58.57	60.64	5.33	7.00	6.16	10.67	12.67	11.67
Sem $\pm$	1.77	1.84		0.26	0.35		0.35	0.29	
CD (P=0.05)	5.31	5.50		0.79	1.06		1.06	0.86	

The length (shoot and root) of henna seedlings recorded after 15 days of seed placement in petridishes was significantly influenced by different treatments (Table 2). Mean data showed that the largest mean shoot length of 6.24 cm was in NaCl treatment followed by water soaking (5.57 cm) and sand scarification (5.53 cm) treatment compared to control (4.43 cm). But lowest shoot length was recorded in H_2SO_4 treated solutions. Similar trend was obtained in root length of the seedlings. Weight of seedlings (fresh and dry) was not significantly influenced by different treatments (Table 3). However, the maximum fresh as well as dry weight was obtained in the seedlings produced under NaCl treatment followed by water soaking treatment. It was under control but slightly lower in H_2SO_4 treated solution.

Table 2. Effect of different treatments on shoot and root length of henna seedlings

Treatment	Shoot length (cm)			Root length (cm)		
	2003	2004	Mean	2003	2004	Mean
T_{1}- Control	4.35	4.52	4.43	1.16	1.09	1.12
T_{2}- Sand scarification	5.26	5.80	5.53	1.35	1.32	1.33
T_{3}- Water soaking	5.38	5.79	5.57	1.49	1.37	1.43
T_{4}- H_2SO_4 (10%)	3.30	3.62	3.46	1.03	1.00	1.01
T_{5}- HCl (10%)	3.43	3.67	3.55	1.10	1.05	1.07
T_{6}- NaCl (5%)	6.25	6.24	6.24	1.62	1.53	1.57
T_{7}- KCl (5%)	5.34	5.38	5.36	1.45	1.29	1.36
T_{8}- $CaCl_2$ (1%)	5.32	5.21	5.26	1.38	1.25	1.31
Sem $\pm$	0.14	0.14		0.05	0.03	
CD (P=0.05)	0.42	0.41		0.14	0.09	

Table 3. Effect of different treatments on fresh and dry weight of henna seedlings after 15 days of sowing

Treatment	Fresh wt of seedlings (mg)			Dry wt of seedlings (mg)		
	2003	2004	Mean	2003	2004	Mean
T_{1}- Control	3.27	3.83	3.55	0.27	0.20	0.23
T_{2}- Sand scarification	4.10	3.63	3.86	0.23	0.30	0.26
T_{3}- Water soaking	4.37	4.27	4.32	0.20	0.33	0.26
T_{4}- H_2SO_4 (10%)	3.63	3.27	3.45	0.20	0.27	0.23
T_{5}- HCl (10%)	4.27	3.63	3.95	0.20	0.27	0.23
T_{6}- NaCl (5%)	4.80	4.50	4.65	0.30	0.37	0.33
T_{7}- KCl (5%)	4.13	3.73	3.93	0.20	0.30	0.25
T_{8}- $CaCl_2$ (1%)	3.93	3.63	3.78	0.17	0.27	0.22
SE $\pm$	0.31	0.26		0.03	0.03	
CD (P=0.05)	NS	NS		NS	NS	

Vigour indices of henna seedlings were measured after 15 days of seed placement in petridishes, which were also significantly influenced by different treatments (Table 4). On average, vigour index I was recorded maximum (568.34) in NaCl treatment followed by water soaking (484.05) and sand scarification (437.58) treatment compared to control (261.43). The lowest vigour index was obtained in H_2SO_4 treatment. Similar trend was observed in vigour index II. Acids (H_2SO_4 and HCl) treatments caused negative effects on germination percentage, speed of germination, seedling length and vigour indices of seedlings. It might be due to over scarification of seeds (Hadidi, 1996).

Table 4. Effect of different treatments on the vigour indices of henna seedlings

Treatment	Vigour Index I			Vigour Index II		
	2003	2004	Mean	2003	2004	Mean
T_{1}- Control	278.52	244.35	261.43	13.40	8.71	11.05
T_{2}- Sand scarification	428.33	446.84	437.58	15.26	18.84	17.05
T_{3}- Water soaking	483.45	484.66	484.05	13.99	22.59	18.29
T_{4}- H_2SO_4 (10%)	167.20	171.45	169.32	7.73	9.94	8.83
T_{5}- HCl (10%)	203.19	197.37	200.28	8.88	11.17	10.02
T_{6}- NaCl (5%)	593.42	543.26	568.34	22.63	25.73	24.18
T_{7}- KCl (5%)	410.15	379.45	394.80	12.09	17.08	14.58
T_{8}- $CaCl_2$ (1%)	419.91	377.81	398.86	10.44	15.68	13.06
SE $\pm$	14.37	12.23		1.61	1.91	
CD (P=0.05)	43.09	36.68		4.83	5.74	

The higher per cent of germination, speed of germination, length of seedlings, weight of seedlings and vigour of seedlings that were obtained in NaCl treatment followed by water soaking and sand scarification might be due to its favourable effects. The treatments improved the seed coat permeability to water, gases and enzymes present in the seeds. Similar results were reported by Mishra and Sahoo (2003) in tomato and cauliflower. They stated that activity of amylase and dehydrogenase enzymes present in the seeds was higher in NaCl treatment, which improved the germination per cent, higher growth, weight and vigour of seedlings. Initiation of cell elongation in embryonic axes, upon hydration has long been recognized as the key element of seed germination (Mohar and Schopfer, 1995).

Hence, the rate and capacity for hydration seems to be related to the regulation of the process of germination.

Early events of seed germination were characterized by imbibitional uptake of water to saturate (physical hydration) the whole system (Osborne *et al*., 2002) followed by another spell of water uptake, which seemed to be critical for germination since turgidity developed as a consequence of water uptake initiated the elongation growth of embryonic axes (Mohar and Schopfer, 1995). Henna seeds posses hard seed covering which hinders water absorption and gaseous exchange. It prevents emergence of radicle and plumule. The treatments comprising Nacl, water soaking and sand scarification showed more water absorption, gaseseous and enzymatic activity and facilitated early start, completion and higher germination. Similar findings have also been reported in ber by Singh *et al*. (2001).

The above findings showed the effects of different treatments especially NaCl followed by water soaking and sand scarification on germination behaviour of henna seeds. The NaCl treatments improved germination per cent, emergence and vigour of henna seeds. These improvements were due to breaking of hard seed coat, higher permeability of water and gases and increased activity of amylase and dehydrogenase enzymes. Among the treatments, NaCl (5%) proved to be most effective in enhancing germination per cent, emergence and vigour of henna seeds. The water soaking (72 hours) and sand scarification (10 min.) treatments also showed higher values of the above per cents.

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IDENTIFICATION OF YELLOW RUST RESISTANT CULTIVARS AND GENOTYPES OF BARLEY *(Hordeum vulgare L. Emend. Bowden)* BASED ON SLOW DISEASE DEVELOPMENT

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ABSTRACT

A total of 159 cultivars and advanced genotypes of barley (*Hordeum vulgare L. Emend. Bowden*) were tested against four pathotypes, St 57 (0S0), St M (1S0), St 24 (0S0) and St 4 (4S0) of yellow rust caused by *Puccinia striiformis* (Westend) *f. sp. hordei* during 2003-04 and 2004-05. Periodic recording of rust was done and area under disease progress curve (AUDPC) calculated. The genotypes, HBL 393, PL 781, PL 78, NDB 1276, NDB 1280, NDB 1295, RD 2634, RD 2660, RD 2671, BH 649, BH 657, BHS 367, HUB 173, HUB 174, HUB 176, HUB 177, JB 40, JB 47, DWRUB 57, DWRUB 60, VLB 90, VLB 91, VLB 96 and cultivars HBL 276, DWR 28, RD 2508 and K 603 showed less value of AUDPC (0.1-200.0) and categorized as slow rusting types. Out of these, DWRUB 57, DWRUB 60 and DWR 28 are malting type barley. The genotypes identified may be useful in breeding for yellow rust resistance and the varieties may be cultivated in the northern hills and plains in India to minimize the losses caused by this disease.

Key words: Barley, *Hordeum vulgare*, Yellow rust, Slow disease development, Resistant genotypes, *Puccinia striiformis f.sp. hordei*

INTRODUCTION

Barley (*Hordeum vulgare L. Emend. Bowden*) suffers from a number of diseases. Yellow or stripe rust caused by *Puccinia striiformis* (Westend) *f. sp. hordei*, is a major disease of barley in India and other countries (Mathre, 1997). Since chemical control of yellow rust of barley is not economically feasible, therefore, durable rust resistant barley varieties are needed to minimize the yield losses. Regular

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efforts are made to screen the entries of barley in advanced yield trials against yellow rust under artificially created epiphytotics. As a result, only the resistant entries showing average coefficient of infection (ACI) up to 15.0 are identified and released for cultivation at farmers' fields in India. However, one of the important concerns of breeders is the specificity and durability of the disease resistance incorporated in their cultivars. With the discovery of physiological specialization in rusts by Stakman *et al*. (1962) and the classification of the genetic basis of resistance (Flor, 1956), the hypersensitive type resistance was incorporated in many cultivars. Although the hypersensitive type host resistance is very effective in reducing the epidemic build up and is easy to manage in breeding programmes due to its monogenic characteristics, but it is short-lived in nature. Improper use of race specific resistance genes in commercial scale led to their erosion within a short time. It has resulted in narrowing of the useful genetic diversity for resistance genes and has created the necessity of continuing search for more durable type of resistance. There is a great step in improving the durability of the intrinsically "non-durable" type of resistance by gene pyramiding. Another possibility would be to identify and introduce resistant types that can be intrinsically durable like partial resistance. There are reports that this type of resistance is durable and race non-specific (Kuhn *et al*., 1978). Partial resistance is characterized by a slow epidemic build up despite a high infection type indicating a compatible host-pathogen interaction (Parlevliet, 1975). Partial resistance may be such an alternative and in several plant-pathosystems, it has been demonstrated quantitative inheritance. Nayar *et al.* (2003) emphasized the importance of slow rusting cultivars in wheat to keep the disease below threshold level and decrease the chances of selection of new pathotypes. To increase the diversity at target areas, diverse vertical resistance genes can supplement the effect of slow rusting resistance at the source areas. Keeping in view of above, the entries of advanced and initial varietals trials and check varieties or cultivars of barley, both food and malt type, were screened at Karnal which is one of the important areas of incidence of yellow rust.

MATERIALS AND METHODS

A total of 159 entries of released cultivars and elite genotypes of barley were planted at Karnal in mid November during 2003-04 and 2004-05 crop seasons. Each entry was planted in 1 m row length with row-to-row spacing of 25 cm. The infector row, composed of highly susceptible varieties like Jyoti, Rajkiran, RD 31, RD 103 and RS 6, was repeated after every 20-test entries as well as around the borders of screening block so as to keep maximum disease pressure on test entries. The crop was raised as per recommended agronomic practices. The inocula of most virulent

yellow rust pathotypes, St 57 (0S0), St M (1S0), St 24 (0S0) and St 4 (4S0) were initially collected from rust laboratory, Flowerdale, Shimla and each pathotype was multiplied separately on infector plants grown inside poly house at 23± 2 ^{0}C. The fresh urediospores were collected from such plants after proper development of rust pustules by using spore collector vacuum pump designed for this purpose. The spore suspension was prepared in water using about 10 drops of “Tween 20” spreader and spore concentration was adjusted up to 10^4 spores/ml. Freshly prepared spore suspension was used for inoculation in the field. The inoculations of rust were done at tillering stage by injecting the suspension into the plants, using hypodermic syringe initially and foliar sprays later on. Proper field moisture was maintained by timely irrigation and spray of water during the evening. The first record of rust was taken when the spreader plants showed disease up to 30 S, followed by two more records at weekly intervals by taking both severity and response using the "Modified Cobb's" scale (Peterson *et al*., 1948). The coefficient of infection (CI) was calculated separately for each test line by assigning 0.2, 0.4, 0.6, 0.8 and 1.0 value to infection responses, R, MR, X, MS and S, respectively and multiplying these with severity of rust. The area under disease progress curve (AUDPC) was calculated by following the method used by Shaner and Finney (1977). The genotypes which were getting lower value of AUDPC (0.1-200.0) were categorized as slow rusting type. Results of two years of experimentation were averaged to arrive at single figures.

RESULTS AND DISCUSSION

The details of the highest rust record, AUDPC value of each genotype and check varieties are presented in Table 1. The highest rust record of infector lines was 100S with AUDPC value, 2520.0. The highest rust record of test entries during two crop seasons was in the range of 0-100S and AUDPC value was in the range of 0.0-2170.0 which indicated a high variability to rust resistance. The entries that showed high resistance to pathotypes of yellow rust are shown below:

Highly resistant (AUDPC =0.0)

Genotypes: HBL 391, HBL 404, HBL 405, HBL 410, HBL 414, HBL 415, PL 762, PL 770, PL 796, K 675, K 713, K 760, K 782, K 783, K 786, K 789, K 791, K 796, RD 2655, RD 2658, RD 2661, RD 2666, RD 2667, RD 2668, RD 2669, RD 2670, RD 2671, RD 2672, RD 2673, RD 2674, RD 2675, RD 2676, RD 2677, RD 2678, RD 2679, RD 2680, RD 2681, RD 2682, RD 2683, RD 2684, RD 2685, RD 2686, RD 2687, RD 2688, RD 2689, RD 2690, RD 2691, RD 2692, RD 2693, RD 2694, RD 2695, RD 2696, RD 2697, RD 2698, RD 2699, BH 553, BH 646, BH 648, BH 673, BH 850, BH 851, BH 854, BH 855, BHS 362, BHS 364, BHS 365, BHS 366,

BHS 368, BHS 369, BHS 370, BHS 371, JB 46, DWRUB 52, DWRUB 54, DWRUB 58, DWRUB 59, DWRUB 61, VLB 89, VLB 92, VLB 94, VLB 95, VLB 97.

Cultivars: HBL 113, BHS 169, RD 2552 and RD 2624.

These genotypes although are highly resistant to yellow rust but may not be stable for a longer period. They may create unwanted pressure on the pathogen to evolve new pathotypes. However, there were few genotypes, both in advanced and initial varietal trials, which were of slow disease developing type. They are listed below:

Slow rusting types: AUDPC value ranging from 0.1-200.0

Genotypes: HBL 393, PL 781, PL 783, NDB 1276, NDB 1280, NDB 1295, RD 2634, RD 2660, RD 2671, BH 649, BH 657, BHS 367, HUB 173, HUB 174, HUB 176, HUB 177, JB 40, JB 47, DWRUB 57, DWRUB 60, VLB 90, VLB 91, VLB 96

Cultivars: HBL 276, DWR 28, RD 2508 and K 603.

These entries showed slow rate of rust development and reduced the risk of epidemic at farmers' fields. Johnson and Wilcoxson (1979) reported that in case of leaf rust of barley, slow rusting reduced yield losses in terms of the ratios of yield and 500-kernel weight from healthy plants to yield and 500-kernel weight from rusted plants of a particular variety. When AUDPC was used to express the nature of rusting in a particular variety, using an arbitrary figure of 200 and below for slow-rusting varieties and above 200 for fast-rusting ones, kernel-weight ratio and yield ratio decreased with increase in AUDPC. They suggested that an AUDPC value of 300 or less should result in a loss of 10% or less, in yield and kernel weight when an epiphytotic begins as plants reach the 50% heading stage. Andres and Wilcoxson (1986) reported that the AUDPC, used to estimate slow rusting against leaf rust in barley, was larger for all cultivars and genotypes in a severe epidemic than in a mild one. Differences among cultivars and lines for AUDPC were more distinct in the severe epidemic. The ranking of the cultivars and lines according to AUDPC was similar in both epidemics. They suggested that testing for the slow rusting type of resistance should be done in severe epidemics with inclusion of cultivars as control that are known to rust slowly or rapidly. Johnson and Wilcoxson (1978) reported that in the fast-rusting varieties Manker, Speciale, Larker and Beacon, *P. hordei* had a shorter latent period (Days for 50% of the uredia to form), and produced more uredospores/unit area of leaf surface, more spores/uredium, more uredia/unit area of leaf surface and larger uredia, than in the slow-rusting barley varieties, MN 7572, MN 7544, MN 9062 and Rogers. Significant differences in certain components were not always observed between slow rusting lines and fast rusting varieties. The components of rust development were significantly correlated with each other and

with the area under the disease progress curve. A method of evaluating chlorosis, pustule formation by yellow rust (*P. striiformis*) separately and results is proposed to simplify estimation of the infection rate by Schmiedeknecht *et al*. (1976). The slow rusting genotypes identified against yellow rust also possess high yielding character.

Table 1. Yellow rust score and AUDPC value of released varieties and advanced entries at Karnal centre (2003-04 & 2004-05)

Sl. No.	Entry	AUDPC	Highest rust record	Sl. No.	Entry	AUDPC	Highest rust record
1.	HBL 391	0.0	0	41	K 786	0.0	0
2.	HBL 393	35.0	5MR	42	K 789	0.0	0
3	HBL 404	0.0	0	43	K 791	0.0	0
4	HBL 405	0.0	0	44	K 792	366.8	40S
5	HBL 410	0.0	0	45	K 804	457.8	50S
6	HBL 414	0.0	0	46	RD 2634	142.8	10MS
7	HBL 415	0.0	0	47	RD 2636	238.0	20MS
8	DWR 46	245.8	20MS	48	RD 2655	0.0	0
9	DWR 51	422.8	30MS	49	RD 2658	0.0	0
10	PL 751	504.0	30MS	50	RD 2660	18.2	10MR
11	PL 762	0.0	0	51	RD 2661	0.0	0
12	PL 768	868.0	60MS	52	RD 2666	0.0	0
13	PL 770	0.0	0	53	RD 2667	0.0	0
14	PL 772	338.8	40MS	54	RD 2668	0.0	0
15	PL 781	77.0	10S	55	RD 2669	0.0	0
16	PL 782	162.4	30S	56	RD 2670	0.0	0
17	PL 783	30.8	10MS	57	RD 2671	56.0	10MR
18	PL 796	17.5	5MS	58	RD 2672	0.0	0
19	NDB 1245	1890.0	80S	59	RD 2673	0.0	0
20	NDB 1246	2170.0	100S	60	RD 2674	0.0	0
21	NDB 1252	1470.0	80S	61	RD 2675	0.0	0
22	NDB 1276	33.6	10MS	62	RD 2676	0.0	0

(Contd…)

Sl. No.	Entry	AUDPC	Highest rust record	Sl. No.	Entry	AUDPC	Highest rust record
23	NDB 1280	16.8	5MS	63	RD 2677	0.0	0
24	NDB 1281	42.0	10MS	64	RD 2678	0.0	0
25	NDB 1289	324.8	60S	65	RD 2679	0.0	0
26	NDB 1293	226.8	40MS	66	RD 2680	0.0	0
27	NDB 1295	42.0	10MS	67	RD 2681	0.0	0
28	K 675	0.0	0	68	RD 2682	0.0	0
29	K 713	0.0	0	69	RD 2683	0.0	0
30	K 723	892.5	40S	70	RD 2684	0.0	0
31	K 745	1456.0	100S	71	RD 2685	0.0	0
32	K 758	2310.0	100S	72	RD 2686	0.0	0
33	K 759	2170.0	100S	73	RD 2687	0.0	0
34	K 760	0.0	0	74	RD 2688	0.0	0
35	K 761	1610.0	80S	75	RD 2689	0.0	0
36	K 764	1064.0	80MS	76	RD 2690	0.0	0
37	K 767	282.0	20MS	77	RD 2691	0.0	0
38	K 768	1456.0	80S	78	RD 2692	0.0	0
39	K 782	0.0	0	79	RD 2693	0.0	0
40	K 783	0.0	0	80	RD 2694	0.0	0
81	RD 2695	0.0	0	122	JB 46	0.0	0
82	RD 2696	0.0	0	123	JB 47	182.0	20S
83	RD 2697	0.0	0	124	JB 48	308.0	40S
84	RD 2698	0.0	0	125	JB 75	840.0	40MS
85	RD 2699	0.0	0	126	DWRUB 52	0.0	0
86	BH 553	0.0	0	127	DWRUB 53	351.4	60MS
87	BH 646	0.0	0	128	DWRUB 54	0.0	0
88	BH 648	0.0	0	129	DWRUB 55	310.8	30MS
89	BH 649	63.0	10MR	130	DWRUB 56	476.0	40MS
90	BH 657	23.8	5MR	131	DWRUB 57	2.0	TMR

(Contd…)

Sl. No.	Entry	AUDPC	Highest rust record	Sl. No.	Entry	AUDPC	Highest rust record
91	BH 661	644.0	40MS	132	DWRUB 58	0.0	0
92	BH 663	450.8	40MS	133	DWRUB 59	0.0	0
93	BH 665	434.0	30MS	134	DWRUB 60	14.0	5MS
94	BH 673	0.0	0	135	DWRUB 61	0.0	0
95	BH 674	434.0	30MS	136	VLB 89	0.0	0
96	BH 676	282.8	20MS	137	VLB 90	56.0	20MS
97	BH 850	0.0	0	138	VLB 91	2.1	TR
98	BH 851	0.0	0	139	VLB 92	0.0	0
99	BH 854	0.0	0	140	VLB 93	448.0	30MS
100	BH 855	0.0	0	141	VLB 94	0.0	0
101	BHS 362	0.0	0	142	VLB 95	0.0	0
102	BHS 364	0.0	0	143	VLB 96	11.2	5MR
103	BHS 365	0.0	0	144	VLB 97	0.0	0
104	BHS 366	0.0	0	145	VLB 98	0.0	0
105	BHS 367	91.0	30MS	146	HBL 276 (C)	35.0	10MS
106	BHS 368	0.0	0	147	BHS 352 (C)	532.0	40MS
107	BHS 369	0.0	0	148	JYOTI (C)	1960.0	100S
108	BHS 370	0.0	0	149	K 603 (C)	100.0	100S
109	BHS 371	0.0	0	150	DWR 28 (C)	145.6	30MS
110	HUB 173	100.8	20MS	151	HBL 113 (C)	0.0	0
111	HUB 174	50.4	5MR	152	BHS 169 (C)	0.0	0
112	HUB 175	338.8	40MS	153	K 551 (C)	924.0	80MS
113	HUB 176	3.5	TR	154	NDB 1173 (C)	1008.0	60MS
114	HUB 177	56.0	10MR	155	RD 2508 (C)	84.0	10MS
115	HUB 178	1610.0	80S	156	RD 2035 (C)	2170.0	100S
116	HUB 179	1960.0	100S	157	RD 2552 (C)	0.0	0
117	HUB 180	490.0	60S	158	RD 2624 (C)	0.0	0
118	JB 31	2170.0	100S	159	LAKHAN (C)	1456.0	80S
119	JB 40	9.8	5MR	160	Infector	2520.0	100S
120	JB 42	504.0	60S				
121	JB 44	364.0	40S				

C- Released check variety

The slow rusting genotypes may be used as donor lines for stripe rust resistance breeding in barley to minimize yield losses in northern hills and plain zones of India and the feed and food varieties HBL 276, RD 2508, K 603 and malt variety DWR 28, may be cultivated in their respective agro-climatic zone.

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YIELD PERFORMANCE AND BLIGHT SEVERITY OF COLOCASIA (*Colocasia esculenta* var. antiquotum) CULTIVARS DUE TO PLANTING DATES

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ABSTRACT

Three Colocasia cultivars viz., Telia, C-62 and BCC-1 were started planting from 1st March to 15th June at 15 days interval during 2002 and 2003 to study disease severity and tuber yield. The effects of cultivars, year and their interactions showed significant ($P<0.05$) response on disease reaction. The least disease severity (%) was recorded with the cultivars BCC-1 and C-62 planted on 15th March. Delayed planting beyond 15th April to 15th June encouraged the disease severity percentage resulting in reduction in side tuber yield. Cultivar BCC-1 showed the least disease severity and exhibited slow disease behavior as compared to other two cultivars irrespective of planting dates and year of study. However, telia was the most susceptible cultivar with respect to *Phytophthora* blight. The result showed that middle of March with cultivar BCC-1 was found suitable for getting higher tuber yield and less severity of blight disease.

Key words: *Colocasia* cultivars; leaf blight disease; Planting dates; Yield.

INTRODUCTION

Aroids, which were vegetables of minor importance and now gaining popularity as staple vegetables in eastern India specially when other vegetables are scarce in the market due to climatic limitations. Aroids are major sources of calories,

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proteins (rich in cystine), carbohydrates, vitamins and minerals, which are now considered to be a good substitute for potato during monsoon months. Amongst the aroids, the most important and extensive cultivation is taro (*Colocasia esculenta* (L) Schott) grown either commercially or in homestead area. This crop suffers from fungal and other diseases but the most devastating and widely spread diseases but the most devastating and widely spread disease for this crop is leaf blight caused by *Phytophthora Colocasiae* Raci. This disease is reported to occur in India and other western and African countries. In India this disease is serious in the state of West Bengal and other states were it is grown (Thankappan, 1985). In India, two types of Colocasia viz. *Colocasia esculenta* var esculenta and *Colocasia esculenta* var. antiquorum are commonly cultivated and both types are equally affected by this disease. Yield loss is attributed to 25-50% in different countries according to the severity of this disease (Jackson *et al.* 1980). Sporadic works have been done on this disease but systematic and methodical information are not available though the pathogen is old one. The disease is known to occur on June to July-sown crop during the south west monsoon period. As this is mainly cultivated by poor farmers, it is difficult to use costly fungicide to control this disease. As leaf blight requires high humidity, high rainfall and moderate temperatures for rapid development, screening for potential tolerant variety should be carried out when optimal levels of these three factors are prevailing. It is therefore, necessary to determine the suitable dates of planting that permit high and low level of disease for screening the cultivars against leaf blight and escape the disease severity to ensure better yield of the crop.

METERIALS AND METHODS

The experiment was conducted at the Mondouri Research Farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal. Three cultivars; Telia (susceptible) (V_1), C-62 (moderately susceptible) (V_2) and BCC-1 (tolerant) (V_3) and eight dates of planting; 1st March, (D_1), 15th March (D_2), 1st April (D_3), 15th April (D_4), 1st May (D_5), 15th May (D_6), 1st June (D_7) and 15th June (D_8) in 2002 and 2003, were employed in a split-plot design with three replicates. Eight dates of planting were considered as main plots and three cultivars as subplots. The dimension of each plot measured 3.0 m X 3.6 m. Within a plot, the cultivars were planted in rows 60 cm apart and 45 cm spacing between plants in a row. There were 40 plants replicate^{-1} for each cultivar. Recommended agronomic practices were followed to raise the crops. The date of appearance of diseases and the disease severity (%) and type of symptoms were recorded at 7 days interval till 30 days before harvesting of the crop. Yield of side tuber (t ha^{-1}) were recorded during harvest.

Disease severity (%) or PDI for each cultivar was recorded by selecting from 10 randomly selected plants of each replicate by 0-4 point scale (Prasad, 1982). Percent disease severity was calculated using the formula

$$\text{Percent disease severity} = \frac{\text{Sum of all numerical ratings}}{\text{Total number of leaves observed x maximum rating}} \times 100$$

Analysis of variance was carried out to partition the variance due to cultivars, dates of planting and their interactions

RESULT AND DISCUSSION

During 2002 and 2003 the blight disease made its first appearance on an average 112 days in case of variety Telia, 146.5 and 161.5 DAP in C-62 and BCC-1, respectively when planted on 1st March coinciding with the onset of south west monsoon (Table 1). Except the earlier plantings 1st April, the cultivar Telia showed first symptoms of this disease (90 DAP) followed by C-62 (140 DAP) and BCC-1 (150 DAP), respectively. With the most earliest planting (1st March) Telia started showing blight symptoms at 110 DAP while C-62 and BCC-1 showed the occurrence at 146.5 and 161.5 DAP, respectively, whereas March 15 planted crop of Telia, C-62 and BCC-1 showed blight symptoms at 100 DAP, 141.5 and 156.0 DAP, respective Delayed planting caused quick and early appearance of the disease irrespective of the cultivar (Table 1). This is due to onset of monsoon, which provided congenial relative humidity approaching saturation and temperature 28-35^{0}C for development of blight disease (Thankappan, 1985).

Generally upland taro is planted in West Bengal during 1st part of May depending on the arrival of south west monsoon. Susceptibility of this disease varied with the dates of planting during each year. The first planting (1st March) computed the lowest mean disease rating compared to the other planting dates though planting on 15th March did not show any significant difference in disease severity with the first planting during both the years (Table 2). The mean disease severity of the three cultivars increased gradually with delayed planting, which showed lowest severity (14.25%) with first planting and reached to a maximum (41.39%) in the last planting. So, it was clear that late planting succumbed to higher level of blight, severity also associated poor crop growth, decreasing photosynthetic area and bulking rate, ultimately the side tuber yield was much affected.

Table 1. Disease appearance of different cultivars on different days after planting (DAP) in 2002 and 2003

Cultivar	Disease-appearance								
	Telia			C-62			BCC		
	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean
1st March	110	115	112.5	145	148	146.5	160	163	161.5
15th March	100	100	100	140	143	141.5	155	157	156.0
1st April	90	90	90	140	140	140.0	150	154	152
15th April	90	85	87.5	140	138	139.0	150	150	150
1st May	83	80	81.5	135	135	135.0	147	145	146
15th May	80	75	77.5	135	131	133.0	145	143	144
1st June	70	75	72.5	130	130	130.0	140	140	140
15th June	70	75	72.5	120	122	121.0	130	125	127.5

While considering the side tuber yield, it was directly associated with planting dates resulting in the maximum side tuber yield (11.46 t ha^{-1}) with 15th March planting followed by 1st March (10.49 t ha^{-1}). However no significant yield difference was observed between the two dates within the same month (Table 2). There was trend to diseases yield with the advanced on date and lowest yield was recorded from 15 June planting. The highest disease severity was also observed on Telia (39.08%), which directly affected the side tuber production of the cultivar. As a result lower yield was observed. The lower severity percentage showed in BCC-1, which resulted highest tuber yield (Table 2). The trend was similar in both the year.

Table 2. Effect of dates of planting and cultivar on disease severity and side tuber yield of *Colocasia* in 2002 and 2003

Dates of planting	Disease severity (%)			Side tuber yield (t ha^{-1})		
	2002	2003	Meam	2002	2003	Mean
1st March (D_1)	15.29 (22.01)	13.21 (20.50)	14.25 (21.26)	7.42	13.56	10.49
15th March (D_2)	15.35 (21.95)	13.38 (20.68)	14.36 (21.31)	8.53	14.39	11.46

Dates of planting	Disease severity (%)			Side tuber yield (t ha^{-1})		
	2002	2003	Meam	2002	2003	Mean
1st April (D_3)	18.84 (25.05)	16.22 (23.06)	17.53 (24.06)	6.79	10.88	8.83
15th April (D_4)	22.09 (27.75)	20.85 (26.64)	21.47 (27.19)	4.82	7.45	6.13
1st May (D_5)	26.77 (30.81)	25.78 (30.18)	26.27 (30.49)	3.70	5.52	4.61
15th May (D_6)	33.39 (35.13)	30.78 (33.54)	32.08 (34.34)	3.64	5.19	4.42
1st June (D_7)	35.48 (36.36)	34.65 (35.89)	35.06 (36.12)	2.87	4.46	3.66
15th June (D_8)	40.88 (39.55)	41.91 (40.10)	41.39 (39.88)	2.97	4.88	3.92
SEm±	0.583	0.712	0.479	0.381	0.733	0.456
LSD (0.05)	1.67	2.03	1.37	1.09	2.09	1.30
Cultivar:	40.71	37.45	39.08	3.83	6.94	5.39
Telia	(39.53)	(37.53)	(38.53)	-	-	-
C-62	19.55 (25.88)	19.27 (25.48)	19.41 (25.68)	4.73 -	8.48 -	6.06
BCC-1	17.77 (24.08)	17.07 (23.49)	17.42 (23.78)	6.71	9.45	8.08
SEm±	0.499	0.491	0.390	0.452	0.586	0.489
LSD (0.05)	1.96	1.93	1.53	1.77	2.29	1.91

Figures in the parenthesis are average arc sine values

The interaction between dates of planting and cultivars was found significant on blight disease severity and side tuber yield (Table 3 & 4). The higher side tuber yield with March planting might be due to the lowest blight disease severity. Late planting not only adversely affected the yield attributes but also affected the ultimate yield of upland taro.

Table 3. Interaction between cultivars and dates of planting on disease severity (%) in 2002 and 2003 (Mean)

Dates of Planting	Disease Severity							
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8
Telia	25.77	26.85	30.30	32.35	39.08	43.63	49.23	65.43
	(30.47)	(31.15)	(33.37)	(34.65)	(39.69)	(41.33)	(44.56)	(54.03)
C-62	10.93	9.90	12.21	18.08	20.70	26.08	27.28	30.06
	(19.20)	(18.27)	(20.41)	(25.15)	(27.02)	(30.70)	(31.44)	(33.24)
BCC-1	6.05	6.35	10.08	13.98	19.03	26.53	28.68	28.68
	(14.11)	(14.52)	(18.40)	(21.80)	(25.77)	(30.99)	(32.37)	(32.36)

Figure in the paranthesis are average arc sine values

Date of planting : SEm± 0.479 LSD (0.05) : 1.37
Cultivars : SEm± 0.390 LSD (0.05) : 1.53
Dates x Cultivars : SEm± 0.830 LSD (0.05) : 2.37

Table 4. Interaction between cultivars and dates of planting on side tuber yield (t ha^{-1}) in 2002 and 2003 (Mean)

Dates of Planting	Side Tuber Yield							
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8
Telia	8.30	9.48	7.93	4.72	3.33	3.40	2.95	2.98
C-62	11.25	11.35	7.78	6.06	4.28	4.60	3.33	4.18
BCC-1	11.92	13.55	10.78	7.63	6.21	5.25	4.70	4.60

Date of planting : SEm± 0.456 LSD (0.05) : 1.30
Cultivars : SEm± 0.649 LSD (0.05) : 1.91
Dates x Cultivars : SEm± 0.789 LSD (0.05) : 2.25

Mishra (1996) reported that yield loss in tolerant cultivar was quite low (26.26%) in comparison to susceptible cultivar (50.39) according to the state of infection. The appearance of leaf blight is delayed and its subsequent progress is slow in tolerant cultivars as compared to susceptible cultivars of taro (Mishra and Singh 1991.)

Analysis of variance revealed significant ($P<0.05$) differences between cultivars, dates of planting and the interaction between them in both the years and pooled mean (Table 5 & 6).

Table 5. Analysis of variance of *Colocasia* blight severity (%) recorded on three Colocasia cultivars each planted at eight different dates in 2002, 2003 and pooled

Source of varieties	df	2002		2003		Pooled	
		Variance	"F" ratio	Variance	"F" ratio	Variance	"F" ratio
Main Plot		3.79	0.636	11.22	1.93	6.83	1.870
Replicates	2	1713.38	287.22	1383.69	238	1543.79	422.941
Cultivars (V)	2	5.96		5.80		3.65	
Error (a)	4						
Sub Plot							
Date of planting (D)	7	407.11	133.14	484.57	106.18	444.25	214.545
D x V	14	20.24	6.619	14.57	3.19	14.289	6.900
Error (b)	42	3.058		4.56		2.071	

Table 6. Analysis of variance of side tuber yield (t ha-1) of three Colocasia cultivars each planted at eight different dates in 2002, 2003 and pooled

Source of varieties	df	2002		2003		Pooled	
		Variance	"F" ratio	Variance	"F" ratio	Variance	"F" ratio
Main Plot		7.83	1.595	4.02	0.488	5.77	1.01
Replicates	2	52.08	10.607	38.28	4.646	43.61	7.659
Cultivars (V)	2	4.91		8.24		5.69	
Error (a)	4						

Contd...

Sub Plot Date of planting (D)	7	43.37	33.21	149.12	30.79	87.98	47.01
D x V	14	2.13	1.629	4.086	0.844	1.23	0.656
Error (b)	42	1.306		4.84		1.87	

The analysis of variance indicated that cultivars and dates of planting contributed significantly to the total variance. The variation due to cultivars, which is the highest, indicates the variance among the cultivars with respect to blight tolerance. This is supported by the mean blight severity of each cultivar averaged across the 8 dates of planting over the two years. Blight severity level computed for

Telia, C-62 and BCC-1 were 39.08%, 19.41% and 17.42%, respectively. Regardless of the dates of planting, Telia was the most susceptible cultivar, it succumbs to the blight early and has the highest rate of infection, but with respect of C-62 and BCC-1 which permitted a delayed start (about 50-60 days later) with the slowest rate of disease and may therefore be regarded as a potentially rate reducing cultivar. The variance due to the dates of planting and differences between years may be considered as a measure of temporal variation in weather factors. The interaction of cultivars x dates of planting was significant ($P<0.05$) during both the years suggesting a degree of environmental specificity in the varietal response to the blight. This agrees well with the consistent relative tolerance of the three cultivars irrespective of the planting time.

Overall result revealed that planting of the crop by middle of March and cultivar BCC-1 was found suitable for getting higher yield and less severity of leaf blight.

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND NUTRIENT USE EFFICIENCY IN MUSTARD *(Brassica juncea* L.)

SUBHASH CHAND[1]

ABSTRACT

The integrated nutrient management is maintenance or adjustment of soil fertility and plant nutrient supply to an optimum level for sustaining desired crop production through optimization of benefits from all possible sources of plant nutrients. Various sources of plant nutrients such as organic manures, fertilizers and bio-fertilizers were even though applied in mustard in an integrated manner, but no systematic documentation of the effects were made. For this purpose a field experiment was conducted to assess overall effect of integrated nutrient management on yield and nutrient use efficiency in a rust resistant mustard var. 'T-59' (known as Varuna), largely grown in northern part of India). The nutrient sources were farm yard manure (FYM) at two levels, fertilizers at four levels and bio-fertilizers at four levels in a split plot design in the experimental farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. Highest seed yield, stover yield, oil yield, B:C ratio, N,P,K and S uptake was observed with application of FYM@10 t/hectare, along with 45N:30P:15K:30S kg/hectare, and inoculation of *Bacillus megaterium* var. *phosphaticum* + *A. Chroococcum* co-inoculation. Fertilizers 45N : 30P : 15K : 30S kg/ hectare application along with inoculation of *A. chroococcum* increased seed yield of mustard by 23 per cent over control. Farmyard manure and fertilizers had significant interaction effect on yield and post harvest availability of N, P, K and S in the experimental soils.

Key words: Integrated, nutrient use efficiency, yield, *Brassica juncea*.

INTRODUCTION

Fertilizers are very important sources of plant nutrients for increasing agricultural production. The mineral fertilizer could supply one or two nutrients but

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integrated use of macro- and micro-nutrient fertilizers and organic residues would provide N, P, K, S, Zn, Fe and B to plant and soil and resist occurrence of multiple nutrient deficiencies. If sufficient quantity of organic manures areadded along with mineral fertilizers then perhaps there would be no need of adding micronutrients (Parsed, 1999).

There is a great need for more research on biological nitrogen fixation and phosphorus solubilization for energy conservation. Most soils of Rajasthan are low in organic matter content and poor in nitrogen and phosphorus. Hence introduction of efficient strains of bio-fertilizers in such soil may help in boosting up production through fixation of more atmospheric nitrogen and solubilization of insoluble phosphorus in soils. Farmyard manure favorably improves the physical, chemical and biological environment (Chand and Pabbi, 2005). It is recognized that neither organic manure nor chemical fertilizers alone can maintain yield sustainability under modern farming where nutrient turnover is quite high.

The oilseed crops *Brassicas* are the third most important edible oil source after soybean and palm, accounting for over 13.2 per cent of world's edible oil supply. In India, mustard and rapeseed are the second most important oilseed crops after groundnut contributing about 30 per cent of the total oilseeds production (Chand and Somani, 2003). As mustard is most prevalent in Rajasthan, therefore, an investigation was carried out here to document the effect of organic manures, fertilizers and bio-fertilizers for improving the yield and nutrient use efficiency.

MATERIALS AND METHODS

A field experiment was conducted during rabi 1999-2000 on a typic Haplustepts soil at the research farm of the Rajasthan College of Agriculture, Udaipur. The soil of the experimental field was clay loam in texture, non-saline (EC 0.87dSm^{-1}), alkaline in reaction (pH 8.4), available N,P,K and S was 343.3 kg ha^{-1}, 21.4 kg ha^{-1}, 165.6 kg ha^{-1} and 7.9 mg kg^{-1}, respectively. Two levels of farm yard manure (0 and 10 t ha^{-1}) and four levels of chemical fertilizers (0,50,75 and 100% of recommended dose based on soil test) were applied in main plots and four levels of biofertilizers inoculants (No biofertilizers, *Basillus megaterum* var. *phosphaticum*, *Azotobacter chroococcum and B. megaterum var. phosphaticum + A. chroococcum)* were inoculated in sub plots. In all there were thirty-two combinations with three replications in split plot design. Crop was harvested plotwise and yield recorded in kg ha^{-1}. Nutrient content in plant samples were determined by di-acid using nitric and perchloric acid (Method No. 5&9 of USDA Handbook, Richards (1968). Nitrogen content was determined by using colorimetric method as suggested by Lindner (1994). Phosphorus in the plant was analysed by Method No.61, Richards (1968) method of colour development. Potassium was determined by flam photometerically and sulphur in plant samples was determined by tyrbidemetric method as described

by Chesnin and Yien (1951). Total uptake of N, P, K and S was calculated by adding together the uptake of seeds and stover.

Soil samples were collected after harvesting of the crop and analysed for available nitrogen (Subbhia and Asija, 1956), phosphorus (Olsen *et al.*, 1954), potassium (Richards, 1968) and sulphur (Ensninger, 1954). BCR of individual treatments were computed. Oil yield was calculated by multiplying seed yield with oil content.

RESULTS AND DISCUSSION

Yield and Benefit Cost Ratio (BCR)

Highest seed yield, stover yield and oil yield was recorded in the treatment receiving 100% STR of fertilizers (60 N + 40 P + 20 K + 40 S) which contributed 27.8, 49.7 and 44.3 per cent over no fertilizer (Table 1). Highest BCR was observed with the treatment receiving 75% STR of fertilizer (45N : 30 P : 15 K : 30 S). Further increase in the dose of fertilizer decreased the BCR in the present investigation. It was expected due to the law of diminishing return with increasing input doses.

Table 1. Effect of farm yard manure (FYM), fertilizers and biofertilizers on seed, stover, oil yield and benefit cost ratio

Treatments	Yield (kg ha^{-1})			BCR
	Seed	Stover	Oil	
Farm yard manure (FYM)				
Control (Unmanured)	1167	3654	447	1.21
10 t ha^{-1}	1262	4000	497	1.15
SEm ±	11.10	36	7.82	0.02
C.D (0.05)	33.20	109	23.45	NS
Fertilizers (kg ha^{-1})				
No fertilizers	908	2854	351	1.12
30 N:20 P:10 K:20 S	1161	3691	450	1.19
45 N:30 P:15 K:30 S	1361	4277	530	1.33
60 N:40 P:20 K:40 S	1429	4486	557	1.08
SEm ±	15.65	51.70	11.06	0.03
C.D (0.05)	46.90	155.10	33.17	0.10
Biofertilizers				
No biofertilizer	1161	3656	451	1.10
Bacillus megaterium	1185	3747	460	1.13
Azotobacter sps.	1231	3849	479	1.21
B. megaterium + *Azotobacter* sps.	1282	4057	499	1.29
SEm ±	14.00	45.80	8.68	0.03
C.D (0.05)	40.00	130.03	24.64	0.08

Application of FYM 10 t ha^{-1} significantly increased seed yield from 1167.5 to 1262.6 kg ha^{-1}, stover yield from 3654.44 to 4000.88 kg ha^{-1}, oil yield from 447.16 to 497.82 kg ha^{-1} and decreased B:C ratio from 1.21 to 1.15 over no FYM. It was due to favorable effect on soil physical properties, microbial population of the experimental soil.

Use of biofertilizers significantly increased seed yield, stover yield, oil yield and BCR (Table 1). Use of phosphate solubilizing microorganism increased seed yield, stover yield, oil yield and BCR by 2.06, 2.48, 1.96 and 2.73 per cent over no biofertilizer. Combined use of *Bacillus megaterum* var. *phosphaticum* +*Azotobacter chroococcum* showed highest value of seed yield, stover yield, oil yield and BCR (1282.40 kg ha^{-1}, 4057.28 kg ha^{-1}, 499.15 kg ha^{-1} and 1.29 respectively) over no biofertilizers because these biofertilizers supply a part of nutrient demand of crop by fixing the atmospheric nitrogen or mobilizing fixed form of phosphorus (Chand *et al.,* 2004). Seed inoculation with *Azotobacter* and *Azospirillum* showed significant response in improving seed yield of mustard (Chauhan *et al.*,1995).

Interaction effect of fertilizers and farm yard manures

Interaction effect of fertilizers and FYM revealed that seed and stover yield was increased by use of fertilizer (0.50, 75 and 100 per cent doses based on soil test) with FYM 10 t/ hectare or without FYM (Tables 2 & 3). Highest seed yield (1439.82 kg/ hectare) and stover yield (4541.44 kg/ hectare) was recorded in the treatment receiving (60 N: 40 P : 20 K : 40 S kg/ hectare) fertilizer + FYM 10 t/ hectare over control. Twenty five per cent of fertilizer could be saved by applying FYM 10 t ha^{-1} along with 75 per cent fertilizer doses based on soil test.

Table 2. Interaction effect of farmyard manure (FYM) and fertilizers on seed yield of mustard (kg/hectare)

Treatments	Chemical fertilizer @ kg ha^{-1}			
	No fertilizer	**30 N:20 P : 10 K: 20 S**	**45 N:30 P : 15 K:30S**	**60N:40 P: 20K:40S**
Unmanured (Control)	833	1124	1294	1418
FYM 10 t ha^{-1}	984	1199	1427	1440
SEm ±	22.1			
C.D (0.05)	66.4			

Table 3. Interaction effect of farm yard manure (FYM) and chemical fertilizers on stover yield (kg ha^{-1}) of mustard

Treatments	Chemical fertilizers @ kg ha^{-1}			
	No fertilizer	30 N:20 P : 10 K: 20 S	45 N:30 P : 15 K:30S	60N:40 P : 20K:40S
Unmanured (Control)	2591	3547	4075	4432
FYM 10 t ha^{-1}	3117	3834	4510	4541
SEm ±	73.16			
C.D (0.05)	219.33			

Uptake of N, P, K & S and their post harvest availability

Application of fertilizer (0, 50, 75 and 100 per cent of soil test based recommendations) increased the N, P, K and S uptake and their post harvest availability in the experimental soil (Table 4). Application of fertilizer 75 per cent of soil test based recommendations increased N, P, K and S uptake by 54.25, 57.97, 52.52 and 52.24 per cent, post harvest available N, P, K and S by 6.88, 8.07, 12.80 and 17.80 per cent over no fertilizer. It was expected that a part of nutrients, which were not utilized by crop, were left into the soil and increased post harvest available nutrients. Uptake of N, P, K and S and their post harvest availability increased upto 75 per cent doses fertilizer. Further increase in the dose of chemical fertilizer (100 per cent STR) had little effect on these parameters.

Table 4. Interaction effect of fertilizers and bio-fertilizers on nitrogen uptake (kg ha^{-1}) by mustard

Treatments	Chemical fertilizers @ kg ha^{-1}			
	No fertilizer	30 N:20 P : 10 K: 20 S	45 N:30 P : 15 K:30S	60N:40 P : 20K:40S
No inoculation	50.94	62.08	78.27	83.90
Bacullus megaterum	52.31	66.28	80.66	82.93
Azotobacter sps.	54.14	70.09	83.24	88.63
B. megaterum+Azotobacter	55.17	79.58	85.69	90.01
SEm ±	1.81			
C.D (0.05)	5.10			

Application of FYM 10 t ha^{-1} increased N, P, K and S uptake from 67.62, 20.56, 55.61 and 33.04 kg ha^{-1} to 77.87, 23.66, 62.60 and 37.20 kg ha^{-1}, post harvest availability of N, P, K and S from 345.75, 21.29, 175.34 and 8.11 kg ha^{-1} to 365.22, 22.00, 187.07 and 8.65 kg ha^{-1} over no use of farm yard manure (Table 4).

Use of biofertilizer treatments viz, no biofertilizer, use of *Bacillus megaterium* var. *phosphaticum*, *Azotobacter chroococcum* and *B. megaterium* var. *phosphaticum* + *A. chroococcum* increased N, P, K and S uptake (Table 4) but had no significant effect on their post harvest availability in the soil. Use of *A. chroococcum* increased uptake of N, P, K and S by 7.58, 5.64, 5.25 and 5.45 per cent over no biofertilizer because use of biofertilizer supply a part of nutrients demand of crop by fixing the atmospheric nitrogen and mobilizing fixed form of phosphorus.

Interactione effect of fertilizer and bio-fertilizer on N-uptake

Application of increasing dose of fertilizer (0, 50, 75 and 100 per cent STR) with biofertilizer alone or in combination significantly increased N-uptake in the present study (Table 5). Use of *B. megaterium* var. *phosphaticum* + *A. chroococcum* with fertilizer 60N : 40P : 20K : 40S kg ha^{-1} increased N-uptake by 76.7 per cent which was highest value 90.01 kg ha^{-1} among all other treatments.

The results showed that the integrated nutrient management was important for mustard production. However, it was further confirmed that neither organic sources nor fertilizers alone can achieve the yield sustainability at optimum level under modern farming system where nutrient turnover is quite high. For higher yield of mustard it is advisable to use all the sources of plant nutrients in an integrated manner and in balanced proportions.

Table 5. Effect of farmyard manure (FYM), fertilizers and bio-fertilizer on uptake and post harvest availability of macro (N, P, K & S) nutrient in experimental soils

Treatments	Uptake (kg ha^{-1})				Post harvest availability in soil (kg ha^{-1})			
	N	P	K	S	N	P	K	S
Farm yard manure (FYM)								
Control (Unmanured)	67.62	20.56	55.61	37.20	345.75	21.29	175.34	8.11
10 t ha^{-1}	77.87	23.66	62.60	37.20	365.22	22.00	187.07	8.65
SEm $\pm$	0.74	0.20	0.60	0.40	3.81	0.25	2.09	0.90
C.D.(0.05)	2.20	0.70	2.00	1.10	11.42	NS	6.30	0.27
Fertilizers (kg ha^{-1})								
No fertilizers	53.14	15.87	43.50	25.86	337.98	20.56	166.00	7.47
30 N:20 P:10 K:20 S	69.51	20.91	56.63	33.51	354.47	21.50	183.82	8.15
45 N:30 P:15 K:30 S	81.97	25.07	66.35	39.37	361.25	22.22	187.25	8.80
60 N:40 P:20 K:40 S	86.36	26.58	69.95	41.72	368.25	22.30	187.75	9.08
SEm $\pm$	1.00	0.34	0.85	0.54	5.39	0.35	2.96	0.13
C.D (0.05)	3.13	1.00	3.00	1.62	16.14	1.00	8.90	0.38

Treatments	Uptake (kg ha^{-1})				Post harvest availability in soil (kg ha^{-1})			
	N	P	K	S	N	P	K	S
Biofertilizers								
No biofertilizer	68.80	21.08	56.51	33.57	353.38	21.36	181.33	8.34
Bacillus megaterium	70.54	21.63	57.82	34.31	354.72	21.50	181.07	8.35
Azotobacter sps.	74.02	22.27	52.48	35.40	356.23	21.73	181.25	8.39
B. megaterium + *Azotobacter* sps.	77.61	23.45	62.62	37.18	357.63	21.99	181.17	8.42
SEm $\pm$	0.90	0.29	0.76	0.50	5.10	0.30	2.60	0.12
C.D (0.05)	0.60	0.80	2.20	1.30	NS	NS	NS	NS

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SELECTION CRITERION FOR HIGH YIELDING WHEAT GENOTYPES UNDER NORMAL AND HEAT STRESS CONDITIONS

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ABSTRACT

A study was conducted to assess the effects of heat stress, genetic variability and character association in wheat. Twelve wheat varieties/lines were evaluated in three replicated trials under normal and heat stress condition during 2004-05. Heat stress was imposed by stress condition. Morphological characters were affected due to heat stress when planting was delayed by 60 days. Decline was recorded for grain yield (48.87%), number of spikes m^{-2} (29.61%), days to anthesis (28.24%), days to maturity (28.89 %), 1000-grain weight (24.80%), plant height (9.96%) and grains per spike (8.24%). Phenotypic and genotypic coefficients of variability indicated higher-moderate genetic variability for grain yield, 1000-grain weight, grains per spike, spikes m^{-2} and plant height in both conditions, while moderate genetic variability for days to anthesis in heat stress. Broad sense heritability estimates were moderate for grains per spike and higher for all other characters. Genetic advance as percent of mean was higher for 1000-grain weight in both, for grain yield in late and for spikes m^{-2} in normal planting. Days to anthesis exerted negative direct effect on grain yield and highest positive direct effect was for spikes m^{-2} followed by days to maturity. All the characters had shown non-significant association with grain yield in heat stress. Therefore, under normal conditions, spikes m^{-2} should be used as a criterion for selection of high yielding genotypes and for heat stress, empirical selection approach should be used rather than analytical.

Key words: Wheat, genetic variability, association, criterion, heritability, genotypes

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INTRODUCTION

Wheat is the major winter cereal crop in Pakistan in terms of both area and production. It is cultivated in an area of 8.4 million hectares producing 23.0 million metric tons with an average yield of 2.7 tons per hectare (Anonymous, 2007), which is less than advanced countries. In addition to other factors, the major climatic constraints to wheat production in Pakistan are high temperature particularly at grain filling period. The optimum wheat planting time in Punjab is early November but due to increased cropping intensity, wheat is now being planted after 15th November and is exposed to high temperature at the critical plant developmental stages. Delayed planting reduced the plant height, days to heading, days to maturity and grain filling duration and ultimately showed the reduction in yield and yield components (Mahboob *et al.,* 2005).Wheat yield can be improved by developing wheat cultivars tolerant to heat stress. There was a dire need to calculate the effects of heat stress on the performance of wheat varieties/ lines. Fischer and Maurer (1976) reported that 1^0 C rise in temperature between the end of the tillering and beginning of grain filling reduced the yield by 4%. Ishaq and Ageeb (1991) suggested that hot environment reduced the duration of all developmental stages and high grain yield could only be obtained when anthesis coincided the coolest period.

Dokuyucu and Akkaya (1999) concluded that the grain yield was positively and significantly related to number of heads m^{-2} and path analysis indicated that spikes m^{-2} had positive direct effect on grain yield. Ketata *et al*., (1976) also reported a positive correlation between number of ears per plant and grain yield. Ahmad *et al*. (1987) stated that number of grains per spike and number of tillers per plant was the main yield component contributing significantly to yield. Kumar *et al*. (2004) studied the correlation and path analysis under varying dates of sowing. They reported that grain yield had positive and significant correlation with days to maturity, test weight and number of spikes per meter row length. The correlation between seed yield and yield attributes were significant for all the traits.

The extent of genetic variability, association of different characters and path analysis are the pre requisites to get genetic information responsible for phenotypic behavior and helpful in selection of desired and elite lines for a particular environment or wider environment. The present study was conducted to derive this genetic information, which would be useful for the formulation of breeding strategy and selection of heat tolerant lines.

MATERIALS AND METHODS

Twelve spring bread wheat varieties/lines were sown on 10th November 2004 and 10th January 2005 under irrigated conditions at Wheat Research Institute, Faisalabad. The sowing was accomplished by Norvigian planter in RCB design with three replications keeping rows 27 cm apart and 6 meter long. The fertilizers (100N:85P:0K kg/hectare) and seed rate @ 100 kg/hectare was used to ensure

optimum plant population. The other standard agronomic practices were followed. Data for the following characters were recorded under normal and stress conditions.

1. Plant height (cm)
2. No. of spikes m^{-2}
3. Days to anthesis
4. Days to maturity
5. No. of grains per spike
6. 1000 grain weight (g)
7. Grain yield (Kg/ha).

The recorded data were statistically analyzed according to Steel and Torrie (1980). The phenotypic coefficient of variability (PCV) and genotypic coefficient of variability (GCV) were computed as suggested by Johnson *et al.*, (1966). Estimate of broad sense variability and genetic advance as percentage of mean were computed as suggested by Allard (1960). Genotypic (rg) correlations were calculated from variance and covariance component given by Al-Jibouri *et al.*, (1958). Path coefficient analysis was done according to Dewey and Lu (1959). Heat susceptibility index was calculated as suggested by Fischer and Maurer (1978) by using the equation as follows:

$$S = (1-Y/Yp) / (1-X/Xp)$$

Where Y = yield under stress.

Yp = yield with out stress

X = mean yield over all cultivars under stress

Xp = mean yield over all cultivars under non stress

(1-X/Xp) is defined as stress intensity.

RESULTS AND DISCUSSIONS

Mean squares for all the characters were highly significant ($P \leq 0.01$) in normal and stress conditions, which indicated the presence of sufficient genetic variability in the experimental materials for grain yield and other traits (Table 2).

Table 1. Weekly average maximum and minimum temperatures at Faisalabad during the crop season 2004-05

Month	2004-2005	
	Maximum	Minimum
November 2004 (1st Week)	29.5	10.7
2nd Week	29.2	10.6
3rd Week	27.1	11.5
4th Week	24.1	13.7
December 2004 (1st Week)	25.5	9.0
2nd Week	23.9	6.5
3rd Week	22.9	8.0
4th Week	19.4	5.2
January 2005 (1st Week)	18.3	5.9
2nd Week	21.3	4.5
3rd Week	18.6	3.4
4th Week	16.1	3.8
February 2005 (1st Week)	18.8	7.1
2nd Week	18.7	11.1
3rd Week	16.9	5.8
4th Week	22.2	8.8
March 2005 (1st Week)	25.3	12.3
2nd Week	26.6	13.8
3rd Week	27.1	17.3
4th Week	27.3	13.8
April 2005 (1st Week)	34.0	16.0
2nd Week	30.6	14.1
3rd Week	36.9	17.2
4th Week	35.2	19.0

Source: Annual report 2004-05 WRI, Faisalabad.

Table 2. Analysis of variance for grain yield and other characters in Bread Wheat 2004-05

Characters	Genotypic mean squares	
	Normal	Late
Plant height	89.05**	103.18**
Days to anthesis	7.09**	236.38**
Days to maturity	7.79**	92.42**
Spikes/m^2	1528.05**	15294.72**
Grains/spike	29.26**	82.21**
1000 grain weight	54.12**	90.55**
Grain yield	298276.82**	359736.92**

Under stress conditions most of the characters were altered under high temperature regime. Reduction of grain yield (48.87%), spikes m^{-2} (29.61%), days to anthesis (28.24%), days to maturity (28.89%), 1000 grain weight (24.80%), plant height (9.96 %) and grains per spike (8.24%) were recorded (Table 4).Similar findings were reported by Mahboob *et al*., (2005). In stress conditions advance line V-01078 showed a low heat susceptibility index (0.73) for yield which indicated heat tolerance during the grain filling period as was evident from moderate reduction in spikes m^{-2} and low reduction in 1000-grain weight. Whereas, variety Bhakkar-2000 indicated higher (1.27) heat susceptibility index for yield, higher reduction in spikes m^{-2} and 1000-grain weight (Table 3).

A little difference between phenotypic and genotypic coefficients of variation was observed which indicated less environmental influence on the expression of these characters (Table 4). Overall PCV and GCV values were higher for 1000- grain weight in each planting condition. Number of grains per spike in normal planting showed higher PCV and GCV values whereas, these values were moderate in stress condition. Grain yield in stress condition showed higher PCV and GCV values but it was moderate under normal planting. Under stress condition days to maturity and days to anthesis showed reduced variability as PCV and GCV values were lowest for these characters, which might be due to high temperature effect at terminal growth stage of the crop. Rests of the values for variability coefficients were moderate.

Heritability estimates differentiate between genetic and environmental variability. High heritability estimates for all the characters were found high which indicated that it was under the control of genetic rather than the environment. Breeder should consider heritability estimates along with the genetic advance because heritability alone is not a good indicator of the usable of genetic variability as reported by Masood *et al.* (1986).

High heritability coupled with high genetic advance for 1000-grain weight, spikes m^{-2} and grain yield in each condition indicated that these traits were controlled by additive genes and effective selection could be made for these parameters. Khan (1990) and Masood *et al*. (1986) reported higher heritability and genetic advance for yield and yield components, which indicated additive genetic variation.

Table 3. Mean performance and heat susceptibility index of wheat genotypes 2004-05

Variety	Stress condition				Normal planting			
	Grain Yield	Days to Anthesis	Spike m^{-2}	1000 grain Weight	Grain Yield	Days to Anthesis	Spike m^{-2}	1000 grain Weight
Inq-91	2053 (1.21)[a]	70	333	34.6	5011	103	420	41
AS-02	2438 (1.04)	70	338	32.6	4998	89	429	47
V-00055	2840 (0.79)	72	327	28.6	4611	103	427	40
V-00125	2344 (0.98)	75	317	30.3	4493	105	432	42
V-01078[b]	2936 (0.73)	75	293	37.6	4566	108	471	45
V-02192	2682 (0.90)	73	342	28	4777	112	499	34
V-01180	2474 (0.99)	75	354	26	4790	113	512	38
Bhakkar-02	1985 (1.27)	76	320	28.6	5203	104	527	37
Manthar	2540 (0.92)	77	325	23.6	4635	116	461	32
GA-02	1971 (0.99)	76	314	26.3	2326	111	385	34
V-00183	2234 (1.11)	71	292	35.6	4876	87	448	49
V-01027	2376 (1.01)	75	274	34.6	4691	103	428	44
Mean	2406 (0.49)[c]	74	319	30	4706	105	453	40
SE ±	57.78	0.65	7.03	1.44	58.02	0.72	11.22	1.25

a. Indicate heat susceptibility index b. Variety proposed for high temperature regime, c. Values indicate heat stress intensity

Table 4. Mean performance and genetic parameters for the characters studied

Character	Mean	Reduction %	SE ±	Coefficient of variability		Habitability as %	Genetic advance as %
				PCV	GCV		
Plant height	*N 101.19	9.96	0.39	5.38	5.23	94.45	8.92
	*L 91.16		0.39	6.43	6.36	97.71	11.02
Days to anthesis	N 104.55	28.24	0.39	8.49	8.46	99.35	14.79
	L 73.68		0.39	3.24	3.12	92.55	5,25
Days to maturity	N 139.00	28.89	0.39	3.99	3.97	98.71	6.91
	L 98.83		0.39	1.62	1.51	85.60	2.70
No of spikes/m^2	N 453.28	29.61	0.39	9.27	8.93	92.85	15.10
	L 319.06		0.39	7.07	6.72	90.27	11.20
No. of grains/spike	N 39.66	8.24	0.41	13.20	10.07	58.20	13.46
	L 36.39		0.40	8.58	7.45	75.41	11.34
1000-Grain weight	N 40.33	24.80	0.39	13.62	13.23	94.28	22.53
	L 30.33		0.39	14.00	13.18	88.57	21.76
Grain yield Kg/ha	N 4706.41	48.87	0.39	7.36	7.25	97.19	12.55
	L 2406.19		0.39	13.10	12.88	96.64	22.22

**N=Normal; *L=Late; PCV= Phenotypic coefficient of variability; GCV= Genotypic coefficient of variability*

Under normal planting correlation coefficient of plant height showed positive and significant correlation with days to anthesis and days to maturity. Whereas, it was negatively and significantly associated with 1000-grain weight and grain yield (Table 5). A positive and significant correlation was recorded between days to anthesis and days to maturity. Kumar *et al*., (2004) had also reported positive significant correlation between yield and days to maturity. 1000-grain weight and grain yield showed negative and significant correlation with days to anthesis. Number of spikes m^{-2} showed negative and non-significant relationship with no. of grains/spike and 1000-grain weight but positively and significantly with grain yield.

The present investigation also revealed that characters, like number of grains and 1000-grain weight had positive and non-significant correlation with grain yield. Under stress conditions plant height had positive and significant association with 1000-grain weight and negatively correlated with number of spikes m^{-2}. A positive and significant correlation was recorded between days to anthesis and number of grains per spike.

The present study also investigated negative and significant relationship between days to anthesis and 1000-grain weight. Number of grains per spike and

1000-grain weight had significant but negative correlation with each other which is fully endorsed by Bakele (1990). In stress conditions, all the characters showed non-significant correlation with grain yield which might be due to hot environment.

Table 5. Estimate of genotypic correlation between yield and yield components in wheat 2004-05

Character		Plant Height (cm)	Days to anthesis	Days to maturity	No. of spikes/m^2	No. of grains/ spike	1000 grain weight	Grain yield Kg/ha
Plant Height (cm)	**N**		0.717*	0.583*	-0.120	0.350	-0.520*	-0.493*
	L		0.041	-0.088	-0.560*	0.290	0.469*	0.023
Days to anthesis	**N**			0.948*	0.298	0.410	-0.870*	-0.404*
	L			0.376	-0.222	0.687*	-0.565*	0.013
Days to maturity	**N**				0.204	0.310	-0.889*	-0.491
	L				-0.195	0.297	-0.344	0.345
No. of spikes/m^2	**N**					-0.093	-0.222	0.604*
	L					-0.122	-0.455	-0.025
No. of grains/ spike	**N**						-0.466	0.116
	L						-0.672*	-0.288
1000-Grain weight	**N**							0.313
	L							0.084
Grain yield Kg/ha	**N**							
	L							

Path coefficient analysis was used to determine the precise contribution of a character to seed yield (Table 6). Under normal planting highest positive direct effect was observed for spike m^{-2} followed by days to maturity, grains /spike and plant height. Days to anthesis exerted negative direct effects on the grain yield. It was evident that character spike m^{-2} had positive correlation with high positive effect on yield, high heritability and genetic advance which emphasized its need for use as a selection criteria under timely sown conditions. The analytical condition showed that under stress conditions although some traits could be improved through breeding but none of these characters could be used as a criterion for the selection of high yielding varieties. Therefore, empirical approach was the best way for the selection of high yielding wheat varieties under stress conditions. The present study concluded that in normal planting spikes m^{-2} could largely be contributed to grain yield. Whereas, in stress conditions it was suggested that a combination of empirical, observation and quantitative measurements might be the best way for the selection of wheat lines that were tolerant to heat stress.

Table 6. Direct and indirect effects of different traits on grain yield in normal and late sown conditions

Character		Plant Height (cm)	Days to anthesis	Days to maturity	No. of spikes/m^2	No. of grains/ spike	1000 grain weight	R (g) correlation with yield
Plant Height	**N**	**0.5498**	-1.7209	0.5742	-0.1494	0.2512	0.0017	-0.4935*
	L	**2.6876**	0.0016	-0.0097	0.5466	-1.1654	-2.0377	0.0230
Days to anthesis	**N**	-0.3940	**-2.4008**	0.9335	0.3719	0.2942	0.0029	-0.4795*
	L	+0.1101	**0.0403**	0.0405	0.2164	-2.8475	2.4528	0.0127
Days to maturity	**N**	0.3206	-2.2764	**0.9845**	0.2551	0.2224	0.0002	-0.4907*
	L	-0.2367	0,0148	**0.1104**	0.1903	-I.2291	1.4950	0.3451
No of spikes/m^2	**N**	-0.0657	-0.7148	0.2010	**1.2491**	-0.0665	0.0007	0.6038*
	L	-1.5038	-0.0089	-0.0215	**0.9769**	0.5070	1.9788	-0.0254
No. of grains/spike	**N**	-0.1924	-0.9847	0.3052	-0.1158	**0.7174**	0.0015	0.1161
	L	0.7560	0.0277	0.0327	0.1195	**-4.1432**	2.9196	-0.2875
1000-Grain Weight	**N**	-0.2858	2.0895	-0.8755	-0.2771	-0.3334	**-0.0033**	0.3132
	L	1.2605	-0.0227	-0,0380	0.4449	2.7840	**-4.3449**	0.0838

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